MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: HERBERT C. HUNTER.

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The MONTHLY WEATHER REVIEW summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Director Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba; Luis G. y Carbonell, Director, Meteorological Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Weather Bureau, Manila Central Observatory, Philippines; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

IN GENERAL.

The month opened with exceptionally high barometric pressure over the Asiatic and Iceland areas and low pressure over the western portion of the North American Continent and adjacent parts of the Pacific Ocean. An area of low barometer, with readings below 29.40 inches, was central near the southern coast of the North Sea, and a severe snowstorm, with gales and low temperature, prevailed over Great Britain, the North Sea, and adjacent coasts.

From the 1st to the 6th an area of low barometer advanced from the Pacific to the Atlantic coasts of the United States, attended by excessive precipitation in the Ohio and middle Mississippi valleys and the lower Lake region, and unusually warm and dry weather in the Gulf States. Following this depression a period of cool, dry weather set in on the Pacific coast.

From the 7th to the 14th the weather in the United States as a whole was warm and dry. Incoming trans-Atlantic steamers reported strong gales that attended the disturbance that past eastward from the American coast on the 7th. During the 7th and 8th heavy weather was experienced over the Leeward Islands of the Lesser Antilles, West Indies.

The night of the 12th the second severe storm of the month set in on the north Pacific coast, a wind velocity of 70 miles an hour being reported at North Head, Wash. This storm crost the continent during the following four days, attended by heavy and destructive rains in the north Pacific States, and by mild temperature and general rains, except in the Southern States, and was followed by a cool wave that carried freezing temperature and snow over Virginia and parts of North Carolina on the 20th, and caused heavy frost in the interior of the east Gulf States.

From the 10th to the 14th barometric pressure considerably above normal in the Iceland area and a depression over southwestern Europe, caused a period of wintry weather over western Europe. During the 16th and 17th the barometer rose above 31.00 inches in the Asiatic area, and a period of abnormally low temperature doubtless prevailed over the countries of southeastern Asia.

A depression over Bering Sea which closely followed the appearance of exceptionally high barometric pressure over the interior of Asia, crost the North American Continent during the first half of the third decade of the month, attended from the 22d to the 24th by heavy rains, local storms, and high temperature in the Gulf States that resulted in flooded streams in that section. In the Northern States temperature was below normal during this period.

On the 23d a decided fall in the barometer occurred in the Asiatic area. On that and the following date an energetic disturbance appeared on the north Pacific coast of the United States. This disturbance advanced with increasing strength to Lake Michigan by the 26th, and moved thence over the Canadian Maritime Provinces by the 27th, attended by strong gales over the Great Lakes and the north Atlantic coast. The depression was preceded and followed by cold waves. During the 24th and 25th an area of high barometer and a moderate cold wave dropt southward and eastward from the British Northwest Territory over Manitoba, the Red River of the North Valley and Lake Superior and extended thence eastward over Ontario, northern New York, and northern New England. The cold wave that followed the passage of the disturbance caused a decided fall in temperature from the northeastern Rocky Mountain slope over the upper Mississippi Valley and Lake region. On the 26th and 27th snow fell in the middle and upper Missouri valleys and thence over the northern Lake region.

On the morning of the 27th the Asiatic area again showed a marked decrease in pressure, and on the morning of the 28th a reading of 29.54 inches was reported at Irkutsk. The giving way of pressure in the Asiatic area for the second time in the third decade of the month afforded the first marked indication of a breaking up of the winter high area of that section and the first indication of a spring adjustment of barometric pressure over the Northern Hemisphere.

The month closed with a deep depression over the interior of the United States that was attended by an extensive rain area over the eastern portion of the country, and followed by an area of high barometer and a cold wave over Manitoba and the north-central States Over the Atlantic area the barometer was very low over Iceland and high over the Azores and southwestern Europe. Over the great Asiatic area after four days' depression the barometer had begun to rise. Over southern latitudes of the north Pacific Ocean pressure was above normal. The Pacific coast States were covered by an area of high barometer. This distribution of pressure indicated for the United States east of the Rocky Mountains several days of comparatively cool weather followed by a week or more of rather rapidly alternating periods of fair and showery weather and mild temperature.

BOSTON FORECAST DISTRICT.*

[New England.]

The month as a whole was mild for the season, with less than the usual amount of precipitation. Storms were fewer and less severe than usual for March, and as a result there was little damage and no great delays to shipping. Storm warnings were displayed in connection with all storms.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

The month was mild and no general cold wave passed over the district. No storm warnings were issued and no general storm visited the west Gulf coast. Frost or freezing temperature warnings were issued on two dates and were partially verified.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

The month was milder than usual, with deficient precipitation, except in the north-central portion of Kentucky. Heavy rains the first and latter portions of the month caused floods in the Ohio River and tributaries. No special forecasts were issued.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

Temperature was considerably above normal and no general cold wave occurred. Warnings for limited areas were, however, issued on five dates, which were followed by decided falls in temperature. Advisory messages were sent on several dates to open ports on Lake Michigan, and no casualties have been reported.—*H. J. Cox, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The month was quiet, with light precipitation and an excess of temperature, except in Utah and southwestern Wyoming. Cold-wave warnings were issued on the morning of the 25th for a cold wave that overspread Wyoming and northeastern Colorado, and on the 31st for southern Wyoming and extreme northeastern Colorado.—*F. H. Brandenburg, District Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month was unusually dry, rain during the first five days being followed by a long rainless period. Frosts, for which ample warnings were issued, were frequent, but did no great injury. Snowfall in the mountains was very light as compared with last year.—*A. G. McAdie, Professor and District Forecaster.*

RIVERS AND FLOODS.

The only really disastrous floods of the month occurred in Washington, Oregon, and northwestern Idaho, where the general heavy rains that fell from the 13th to the 15th, inclusive, were quickly followed by floods, particularly in the smaller streams, resulting in great damage, much inconvenience, interruption to business, and considerable suffering. Railroads were washt out, bridges were torn from their foundations and carried down stream, and outbuildings and loose effects carried away. Many millions of feet of lumber were carried down stream, but this was not entirely an unmixt evil, as it solved the problem of transportation of the lumber to the mills or market with little or no expense. No detailed reports of this flood have been received, and it is impossible to express in figures the extent of losses and damage.

The Columbia River rose but little.

The rainfall of the month over the Ohio watershed was quite abundant, and two floods of fair magnitude were the result. Both were well forecast, and neither did any damage of consequence, altho at Pittsburg, Pa., where the second flood reached a crest stage of 27.3 feet at 1 a. m. of the 20th, about five hundred cellars and basements were flooded, their contents having been previously removed. The first flood began on the 2d, at Pittsburg, and the crest past into the Mississippi on the afternoon of the 18th, the stage of water at Cairo, Ill., being 45.55 feet, 0.55 foot above flood stage. The second flood began on the 19th, at Pittsburg, and at the end of the month the advance waters had just about reached Cairo.

Generally speaking, the Ohio River was high thruout the month, with mean stages of 41.9 and 42.7 feet, respectively, at Cincinnati, Ohio, and Cairo, Ill.

The lower Mississippi River also remained high, its normal condition during this season of the year, and at the end of February the flood crest of that month had just past New Madrid, Mo. The rise continued below, and at Greenville, Miss., the river was still rising slowly when the advance waters of the first Ohio River flood reached that place. The flood stage of 16 feet at New Orleans, La., was first reached on the 9th, and since that date the river has not been below the flood stage.

Warnings of all the high waters were issued whenever necessary, and they were very precise both as to stage and time.

Disastrous floods were also experienced along the interior rivers of Ohio, Indiana, and Illinois. The Wabash and White rivers rose from 7 to 9 feet above the flood stage and thousands of acres of land were under water, bridges were carried away, and several railroads were seriously handicapped by washouts. The Illinois River also rose from 8 to 11 feet above flood stage and caused considerable damage of the usual kind, tho perhaps not so much as in Indiana. In Ohio much less damage was done. These floods were well covered by warnings, except in northern Indiana, where no service is maintained, and thru the advices given much property was saved that otherwise would have been lost or greatly damaged.

The floods in the Grand River of Michigan were the product of a fair rainfall on the 5th and 6th, combined with the run-off from a snowfall that averaged more than twice the normal amount for the month of February. The situation was also complicated by ice gorges between Grand Ledge and Ionia, Mich. Previous to the beginning of the rain nearly the entire length of the river was covered by a solid sheet of ice, averaging more than 1 foot in thickness, but the rain of the 5th and 6th and the warm sunshine from the 9th to the 13th, inclusive, rotted it so that it soon broke up and past down with but little damage. The first warnings were issued on the 7th, and supplementary ones frequently thereafter. The warnings were of great benefit, especially at Grand Rapids, where large quantities of merchandise, etc., were removed to places of safety. The city officials were also enabled, thru a warning given four days in advance, to prevent the flood from reaching the west side of the city.

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

The following remarks by Mr. C. F. Schneider, official in charge of the local office of the Weather Bureau at Grand Rapids, relative to the causes of floods in the Grand River are of interest in this connection. Besides explaining the causes of the floods of the day they are indirectly suggestive of grave future possibilities both on account of deforestation, and of increased rapidity of run-off and constricted channels.

It may be proper at this time for the writer to state what, in his opinion, are the principal causes of these disastrous floods. Many people attribute them almost entirely to the deforestation of the watersheds, and this undoubtedly is a great factor; but still greater factors, I believe, are the extensive system of farm, township, and county drains which cover the watershed, and the encroachment of the people on the lowlands of the river. In Grand Rapids, at the foot of Pearl street, there are two solid blocks of business houses where fifty or sixty years ago the river flowed, and so it is to a greater or less degree at Lowell and Ionia. The lowlands adjacent to the river are dotted with factories and houses. Baxter's History of Grand Rapids tells of numerous floods many years ago, when the water reached stages fully as high, and probably somewhat higher, than those experienced in recent years. Fifty or sixty years ago southern Michigan was one vast wooded expanse interspersed with large swamps that were natural reservoirs. To-day these swamps have nearly all been drained, and every township has its large ditch leading to the nearest creek or river, and the creeks and smaller rivers have themselves been drained to promote the flow of water. All this produces a very rapid congestion of the water, and as an auxiliary of no small proportion must be reckoned the extensive system of tile drainage instituted by the progressive farmers of southern Michigan. For these reasons I would say that altho deforestation is certainly a factor in promoting floods in southern Michigan, it is not so much so as in other parts of the United States, where the land is more hilly and some times much more rocky. The general drainage system of man and his encroachments on the lowlands are the principal causes of flood damage in southern Michigan.

There were moderate floods in the Hudson River from the 14th to the 16th, inclusive, due to ice gorges, and in the Connecticut River from the 29th to April 1st, inclusive. The timely warnings for these floods were much appreciated.

The small floods in the North Branch of the Susquehanna River from the 14th to the 16th, inclusive, past out without attention.

The approach of the floods that began early on the 24th in the Southern rivers had been heralded by the Weather Bureau on the day previous, and farmers and lumberman spent a very busy day, the former in removing stock, etc., to places of safety, and the latter in preparing to remove lumber that had been waiting for such an opportunity.

No unusually high stages were reached and losses and damage were small, as the warnings enabled all to take necessary precautions.

The ice in the Mississippi River between Le Claire and Dubuque, Iowa, went out during the night of the 5th; at Prairie du Chien, Wis., on the 16th; at La Crosse, Wis., on the 11th; at St. Paul, Minn., on the 15th, and at Fort Ripley, Minn., on the 29th.

Navigation at Keokuk, Iowa, opened on the 10th.

The Missouri River remained frozen thruout the month in the vicinity of Wolf Point, Mont., but was practically open elsewhere after the 15th. At Sioux City, Iowa, the break-up occurred on the 3d, and the last ice of the season past Omaha, Nebr., on the 10th.

The upper Connecticut River opened on the 13th at White-river Junction, Vt., and on the 15th at Wells River, Vt. The lower Penobscot River opened on the 27th. The ice gorge in the Hudson River near New Baltimore, N. Y., the last one of the season, disappeared on the 22d, and navigation opened on that date.

The highest and lowest water, mean stage, and monthly range at 210 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

ACCIDENTAL VARIATIONS IN ATMOSPHERIC PRESSURE IN THE UNITED STATES.

By ALFRED J. HENRY, Professor of Meteorology. Dated February 19, 1908.

The auxiliary charts of the Forecast Division of the Weather Bureau contain a record of the 12 and 24-hour pressure changes for the last twenty years. The 12-hour periods extend from 8 a. m. to 8 p. m. and from 8 p. m. to 8 a. m., seventy-fifth meridian time; the first of these represents substantially the day hours, the second the night hours. The 24-hour pressure changes are made directly from the sea-level readings of one day as compared with those of the next. In obtaining the 12-hour changes a correction is applied to the actual difference between the successive, twice daily, readings in order to eliminate the effect of diurnal variation.

Inasmuch as the reduction to sea level on the western plateau and in the western mountain regions is somewhat uncertain, at times, on account of the temperature argument, the changes made from sea-level pressures for those regions may not represent true pressure changes at all times and in all seasons.

Areas of pressure fall or rise move across the United States generally from the west toward the east. Ordinarily each region of falling pressure is followed by a region of rising pressure. Sometimes, however, a second area of falling pressure moves in from the Pacific and gradually overtakes and merges with the preceding area of falling pressure.

In addition to moving areas of pressure change which attend cyclones and anticyclones, pressure is occasionally observed to rise or fall, spontaneously, so far as can be determined, over large areas. In this phenomenon the definite eastward movement, which is a characteristic of the ordinary areas of rise and fall, is absent. Such stationary areas of rise or fall occur mostly in the warm season and in the daytime. Nothing is known as to their cause.

The amplitude of the fall in any region of diminishing pressure bears no relation to the amplitude of the rise in the succeeding area of rising pressure; thus the fall of the barometer in a series of cyclones may be uniformly greater than the rise in the succeeding anticyclones, and vice versa. As a result of these inequalities, the pressure over the continent is in continual fluctuation above and below the general mean. These general up and down pressure oscillations are separate and distinct from the local and moving areas of pressure fall and rise that usually attend the formation of cyclones and anticyclones.

Areas of falling pressure do not necessarily result in the formation of cyclones. In December, 1907, 12 well-marked cyclonic areas moved across the United States, while 19 separate and distinct areas of falling pressure were observed.

In order to determine the ratio of the pressure changes in the day hours to those of the night hours the most important cases of rising and falling pressure over the interior of the continent for December, 1907, were examined. No comparisons of the rate of change during day and night hours were made until after the areas of rising or falling pressure, as the case might be, had passed wholly within and over the interior of the continent.

The average 12-hour rise in pressure in 40 cases during the night hours was 0.32 inch; during the day hours, 0.35 inch. The average 12-hour fall in pressure during the night hours in 45 cases was 0.31 inch; during the day hours, in 41 cases, 0.32 inch. While these results show a slightly greater fluctuation of pressure over the continent during the day hours than during the night hours the differences are small. It is probable

that the warm season would show greater fluctuations by day than by night.

Some of the characteristics of areas of rising and falling pressure are shown on fig. 1. This illustration, in which the ordinates are tenths of inches of pressure change, and the abscissas, time, is intended to show graphically the pressure changes which occurred during the day hours and the night hours in December, 1907, and the fore part of January, 1908. In general the movement is from the Pacific to the Atlantic, but the abscissas do not necessarily show space gained to the eastward. The solid lines represent areas of falling pressure, and the dotted lines areas of rising pressure. The amount of rise or fall is expressed in tenths of an inch. The diagrams are read as follows: No. 1, for example, is the record of an area of pressure fall and its corresponding area of rising pressure that moved from the Pacific coast on the 5th to the Atlantic coast on the 10th. The fall in pressure at the evening observation on the 5th was 0.10 of an inch on the Oregon coast; by the next morning it was 0.48 of an inch in practically the same position. At the close of the third consecutive 12-hour period it had past inland diminishing from 0.48 to 0.28 of an inch. On the evening of the 8th the fall in pressure had diminished to 0.22 of an inch; it then began to rise and continued rising until it past over the Atlantic Ocean on the morning of the 10th.

The dotted line shows that pressure began to rise thirty-six hours after the fall set in, and that it rose steadily until the morning of the 8th, then gradually diminished. If the amount of rise and fall had been equal, then the dotted and the solid lines in the diagram would have been parallel, except for the lagging of the area of rising pressure behind the area of falling pressure.

No. 2 shows a case where the second maximum in the falling curve was not followed by a corresponding inflection in the rising curve.

No. 3 shows a case where the area of falling pressure merged with a much greater area of fall that was moving eastmard directly ahead of it. This case should be considered in connection with No. 2, in which the wave of rising pressure practically disappears on the evening of the 14th. A fresh area of rising pressure appears on No. 3 on the morning of the 13th.

In Nos. 6 and 7 the curves of rising and falling pressure are fairly symmetrical.

Nos. 8 shows a uniform increase in the falling curve from the time it was observed on the Pacific coast until it disappeared over the Atlantic. This is a rather unusual occurrence.

In Nos. 9 and 12 the rising curve is made up of two branches; the branch on the left in each case represents a wave of rising pressure which moved southeastward from the northern Plateau region to the Texas coast and then disappeared over the Gulf of Mexico. The branch to the right developed in higher latitudes farther to the eastward.

A marked increase in the rate of pressure fall produces, as a rule, a corresponding increase in the strength of the surface winds which circulate around the storm center and a rapid eastward extension of the areas of cloud and rain which attend the storm. It is necessary, therefore, that the weather forecaster be constantly on the lookout for a probable increase in the amplitude of the 12-hour pressure fall.

The following precepts with regard to the significance of 12-hour pressure falls have been empirically determined by the writer:

1. A strong 12-hour fall in pressure (.60 to .90 inch) appearing on the north Pacific coast will become only a moderate fall (.20 to .40 inch) when it reaches the Mississippi Valley, if it does not disappear before that time. The attendant cyclone will naturally diminish in strength as it passes over the continent. This rule expresses the fact, whatever the cause, that a highly developed storm suffers loss of energy in crossing the western mountain ranges and plateaus. That the loss of energy is in some manner connected with the work evidently required in raising the system from sea level to the mountain summits and the added friction due to the irregular topography, seems possible. On the other hand it should be remembered that a cyclone may develop on the lee side of the Sierra Nevada, preserve its entity and even increase in strength while crossing the semi-arid region of the Great Basin and the Rocky Mountains. No. 8 illustrates a pressure fall that came from the Pacific, began to increase in Nevada, and developed into a storm of considerable energy in the interior valleys and Atlantic coast districts.

2. The areas of pressure fall that attend severe cyclones in the eastern part of the United States are at the beginning moderately shallow areas, mostly circular, rather than elliptical, in form. The increase in strength is apt to occur suddenly. When the form of an area of pressure fall closely approaches that of a circle, the attendant cyclone will be well marked and will generally increase in strength. The usual form of areas of pressure fall in the United States is that of an oval whose longer dimension generally stretches from the British Possessions to Mexico over a strip 800 to 1,000 miles broad.

3. Two separate areas of pressure fall, one moving eastward across the southern Rocky Mountain region or northeastward over the Gulf States, and the other moving eastward along the northern boundary, are apt to unite in the Mississippi Valley. The amplitude of the fall in the area after merging takes place is greater than in either of the single areas, and severe storms are sometimes caused in this way.

4. Areas of rising pressure whose origin is apparently over the Pacific Ocean, do not produce severe cold as they move across the continent. In the same class are areas of rising pressure that build up over the southern part of the United States in the rear of a sharp and continuous fall in pressure. (See Nos. 10 and 12).

5. The unusually frigid weather that is sometimes experienced in the United States is preceded, almost invariably, by areas of rising pressure that issue either directly from the north or with a strong northerly component. The degree of cold that will follow any certain cyclone in the winter season depends mostly on the geographic position of the succeeding anticyclone. While anticyclones are generally considered as regions of cold west to northwest winds it is important to take note of the region whence they come; thus on the California coast the anticyclones that advance from the southwest, a region of relatively high temperature, have very little effect on terrestrial temperatures in California. In their subsequent course to the eastward they pass over elevated regions of low temperature and occasionally over snow surfaces whereby the temperature of the air in the front of the anticyclone becomes considerably lower than it was in California. As the air descends to lower altitudes, after crossing the Rocky Mountains, the reverse process must obtain and the air must gradually become warmer. No quantitative statement of the amount of warming in the descent is possible, but the fact remains that when the front of the anticyclone reaches the Mississippi Valley the fall in temperature will be great or small according as the existing temperature is above the normal for the time and place, or approximately normal. If the air over the Mississippi Valley is unduly warm as a result of a strong cyclonic indraught from the Gulf of Mexico, then will the fall in temperature on the front of the anticyclone be as much as 16° to 20°. On the other hand when anticyclones issue from the north the conditions are much different. The cold and consequently dense air currents of which the anticyclones are composed flow in a general southerly or southeasterly direction, such a flow being made possible by the previous development of an area of low pressure over the Plains States.

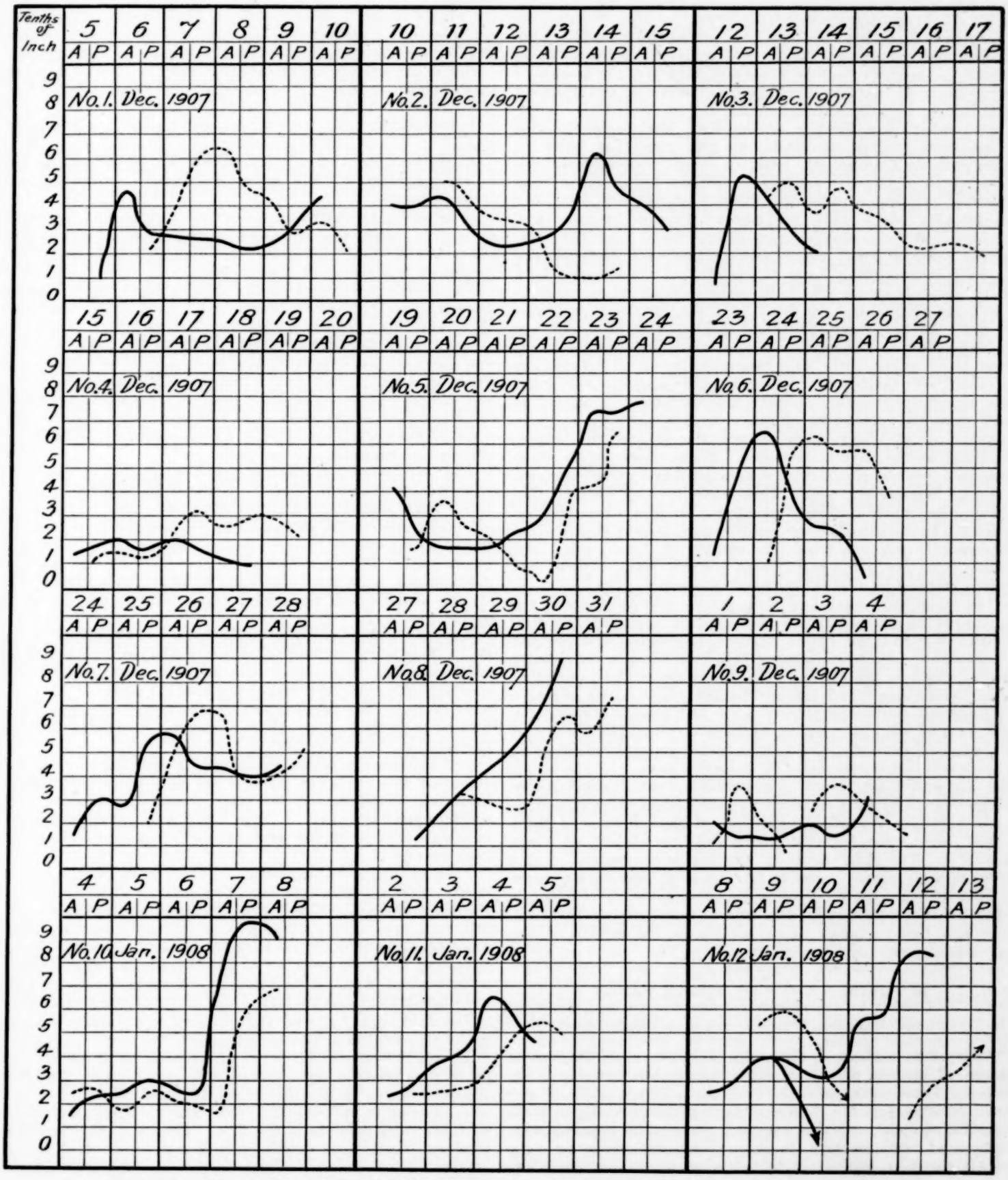

FIG. 1.—Character of 12-hour pressure changes in the United States. (Solid lines indicate a fall, dotted lines a rise in pressure.)

The principal point of entry of these winds into the United States is along the northern border between the eastern slope of the Rocky Mountains and Lake Superior. It is the general impression that they flow southerly in shallow surface currents whose vertical extension is at no time great enough to permit the cold air to flow westward thru the low passes of Wyoming and Colorado into the Great Basin. In confirmation of this view I quote an incident related by Prof. F. H. Loud, in Colorado College Studies, volume XI. The incident relates to observations that were made on a cold wind that suddenly sprang up on October 24, 1904, in front of an approaching anticyclone. There were three parties concerned in the observations, one on top of Pikes Peak (14,108 feet), the second at a camp, 3,000 feet above Colorado Springs, and the third at Colorado Springs (5,981 feet). At the last-named place a great cloud canopy was seen early in the morning approaching from the north; it was attended by a sharp increase in the wind, the latter springing at once to a velocity of 26 miles per hour, and the temperature began to fall. At the camp, 3,000 feet higher, the wind did not begin to blow until four hours later, at which time the cold-wave front at the lower level was probably 50 to 100 miles in advance. On the top of Pikes Peak, only a gentle west wind was experienced, with moderate temperatures. It should be said that the mountain climbers did not set out to make meteorological observations, hence the absence of definite readings at the several altitudes. These observations show clearly, however, the flow of a cold surface current under a mass of warmer air, which it evidently lifts up without disturbing its equilibrium and causing it to flow away on both sides. The diffusion of the cold upward is very slow and in this case it did not reach the summit of Pikes Peak. The moisture in the air was sufficient to form dense clouds, but only a trace of rain fell at the lower station.

The rapid southward flow of extremely cold air is one of the most striking characteristics of the winter climate of the Missouri Valley and the Plains States. The sharp and decided temperature falls which attend these phenomena can hardly be explained on the ground of radiation alone, altho radiation from the air itself and the earth's surface becomes effective in lowering the temperature as soon as the wind abates. On the front of the anticyclones which issue from the northwest the wind velocity over the Plains States generally exceeds 30 miles per hour, occasionally 40 miles per hour. These velocities are sufficiently great to constantly renew the air at any given point and thus maintain the low temperature it had in more northern latitudes, regardless of the influence of insolation during the daylight hours and the warmth of lower latitudes. The chief cause of the low temperatures on the front of anticyclones seems to be, therefore, cooling by transported air from high latitudes plus radiation. The latter is effective in proportion to the rate of movement of the anticyclones, being greater in proportion as the motion of the latter is slower.

IS THERE A TYPE OF STORM PATH?

By EUGENE VAN CLEEF.

(Read before the Association of American Geographers, December 30, 1907.)

In my first studies of the daily weather maps, the movements of centers of storm areas across the country were noted. These were the centers of low pressure areas, or cyclonic storms, and the centers of high pressure areas, or anticyclonic storms.[1] Further research revealed an apparent succession of such centers passing along the same, or very nearly the same, paths. With this observation the possibility of forecasting seemed to be attainable, and I undertook a determination of the paths of type storms. I wish to extend my thanks to Dr. J. Paul Goode, of the Department of Geography of the University of Chicago, for his many valuable criticisms and suggestions while this work was in progress.

Before discussing my methods or results I wish to define three terms:—"Type", "type path", and "type storm."

A "type" is that which is representative.

A "type path" is a well-defined course which is representative.

A "type storm" is a storm (either a high or a low) that is representative of all storms exhibiting nearly the same characteristics.

In as much as storms of the same type should follow the same type paths, and inasmuch as the paths of storms were the available data, the latter were classified with the results described in the following paragraphs.

The MONTHLY WEATHER REVIEW of the United States Weather Bureau gives in detail each month the paths of the centers of high and low pressures crossing the country during the month. A period of ten years, from 1896 to 1905, inclusive, was selected, this length of time being ample as a fair basis for conclusions. This period includes 1,160 paths of "lows" and 928 paths of "highs," or a total of 2,088 paths, averaging 208.8 per year. The paths were plotted upon separate card maps of the United States, size 4 by 6 inches, in order to facilitate classification.

The cards were first classified according to the mean paths of storms, as shown in chart 2[2], Bulletin 20, by Professor Bigelow. This classification could not stand; many storms that really deserved to be alone had to be placed with types. The classification was extremely elastic, but had to be more rigid. Casting aside all suppositions and thoughts of what the type paths ought to be, the cards were arranged by similarity, i. e., all the paths which resembled one another were placed together.

The first assortment was rather rough. Crude as it was, about 30 sets of lows and 24 sets of highs resulted. Not satisfied with this result the cards were reassorted; some were removed from one set and placed with others, or new sets were made. This method was not entirely satisfactory. It seemed now that it would be essential to define the type storm.

In accordance with the definitions given above by me, I reclassified two or three times. But still there was another limitation which seemed necessary, a limitation relative to the width of the "type belt." Four hundred miles was considered as the average width of "storm areas," or possibly a little less than average.

Then recalling the definition of a "type storm," namely "a storm which is representative of all storms exhibiting nearly the same characteristics," and adding the limitation of the path to a type belt 400 miles in width, another classification was attempted. Finally a satisfactory classification was reached including a certain number of sets of similar storm paths, a certain number of unclassified, and a certain number which were incomplete and therefore had to be entirely excluded.

The next step consisted in resolving the various sets into paths representative of each set. This was carried out not by mere superposition, but by a process of elimination. Two paths were charted upon a base map in one color, the resultant was drawn in another color (Charts IX–X); two more were charted in still another color, and their resultant drawn with the same color as in the first. Then the resultant of the two resultants were drawn in a fourth color—thus for four storms. I proceeded by fours in this manner, then resolved

[1] The word "storm" is applied here to any disturbance of the atmosphere, whether due to a *high* barometric pressure or to a *low* one, many of which are not *storms* in the ordinary acceptation of that term.—*C. A.*

[2] This chart 2 of the Weather Bureau Bulletin No. 20 was reproduced in a leaflet entitled "Explanation of the Weather Map," and is not here given as it is easily accessible.

the resultants of the fours[3] until the semifinals (Chart XI) were reached, when these were resolved for the final, and the final plotted alone. This now was my "type" storm of the set in question. Thus carrying out the same process with each set, always treating the paths of highs and lows separately, I obtained a set of lows and highs and plotted them as represented herewith in Chart XII, paths of lows, and Chart XIII, highs.

The lows included 1,160 cases, of which 983 are classified, 57 miscellaneous, and 120 incomplete which can not be considered. The highs included 928 cases, of which 741 are classified; 98 are miscellaneous, of which 57 can not be classified owing to their peculiarity of running northward parallel to the Pacific coast before entering the country and then dispersing along various courses; 89 are incomplete and accordingly can not be considered.

Before discussing these results as types attention is called to a few striking features shown on these charts.

Cyclones, lows, Charts XII and XIV.—Notice first the apparent unity of first appearance in the northwest altho certainly not the origin, with the trend of path into the interior of the country from northwest to southeast, then the dispersion in the Mississippi Valley and the reunion toward the northeast. Again, notice the crossing of the Cordilleras by many of these lows, but the absolute avoidance of the Appalachian region.

There is an apparent, tho not too well defined, tendency for the lows to avoid bodies of water, one belt extending across Sault Sainte Marie, another belt across Michigan, and still other belts passing on either side of Lake Erie, but not crossing it.

Note the parallelism with the coast line of lows moving northeast along the Atlantic coast.

Anticyclones, highs, Charts XIII and XV.—There is an apparent origin in the northwest, as in the case of the lows; then a trend from northwest to southeast, a dispersion in the Mississippi Valley, continued, however, to the Atlantic without reunion.

Here, in contrast with the lows, there is an absence of storm paths in the Cordilleras and a freedom in crossing the Appalachian region.

Two "type-paths" seem to find their origin somewhere off the coast of California and travel northward, entering the country around the northern edge of our maps.

From the statistics at hand, as a matter of interest and possibly significance, I plotted two curves, one (Chart XVI), showing the "Annual variation in storm frequency; average of ten years," indicating a maximum of storms in November, December, and January and a minimum in June, July, and August; the other (Chart XVII) showing the "Secular variation in storm frequency during eleven years," exhibiting an apparent 5-year rythm. Possibly after some fifty years more, statistics alone considered, we may be able to decide definitely as to this rythm.

Charts XII and XIII should represent "types of paths." Keeping in mind the definition of type path and the limitation as to the extent of a type path belt, I sought to learn whether these charts really represent types. No doubt the large number of type paths here shown is open to criticism; it may be said that some of these paths might be consolidated quite readily into one, or that 400 miles is entirely too limited. However, on the contrary, even greater limitations might be set.

Chart XVIII shows two paths of low centers which at first one might believe could be very easily consolidated. They enter the country together in the Puget Sound region and leave it together on the eastern coast, moving along the same course toward the northeast. So far as these two positions are concerned they might be legitimately consolidated. But by following the paths across the continent we find a prominent divergence at Calgary, continuing thru Williston southeastward, reaching a maximum at Charles City, Iowa. It is quite evident that a low on path *A* will not have the same influence on South Dakota in passing eastward, as a low on path *B*. Again, a low of given characteristics in longitude 90° W. will not affect Chicago, for example, on path *A* as it will if on path *B*. From longitude 115° W. to 80° W. a low having certain well-defined characteristics, if following course *B* will be affected by the influence of the western mountain ranges for a longer time than along course *A*. I believe that the Great Lakes[4] are also an important factor in influencing the movements of storms in the vicinity, so that a storm on path *A* would not be affected by the Lakes as one on path *B*. If this be so there is good reason for differentiating finely as long as slight changes in path mean considerable changes in character.

Of course it is much simpler to have but 10 types. It is far easier to determine whether a storm belongs to one of 10 types than to one of 48. Then besides 48 types, there is a total of 364 storms which can not be classified. If the classification had been still more rigid, the number of types would have been increased to half as many again. The presence of the large number of so-called "types" and the possibility of securing more, leads to a slight suspicion as to the soundness of the "type" hypothesis.

Possibly under ideal conditions, such as uniform flat topography, no lakes, no seas, no large rivers, one might be able to determine quite easily and precisely all the type storm paths. But mountains, lakes, seas, oceans, forests, and plains do exist, and are possible factors in the courses pursued by storm areas and in the determination of the effects of a storm on the regions concerned. Local influences[5] are oftentimes enormous factors affecting the characters of highs and lows. As to exactly what their effects may be we know very little. With the numerous possibilities involved in altering the paths and the characters of storms, the difficulties of classifying according to types increase rapidly, and the idea of "types" as a basis for forecasting completely breaks down. I began by assuming that types should enable us to forecast with ease the future position of any storm. But the variations possibly due to the influence of local conditions makes the forecast almost a lottery. The "type" is really no longer a type, except under well-defined conditions. As the same well-defined conditions rarely repeat themselves this means that the type storms rarely repeat themselves; accordingly there is either a type storm for every condition (which means that each storm must be a type in itself) or there is no type.

Waldo[6] recognizes that a large number of types of maps must exist:

> It is possible to class weather maps in a general way according to certain types, but the number of these types is very great. Probably over 100 typical forms would be necessary for such classification; some one of them might occur only at intervals of several years, while others would occur several times in a year.

The very fact that there is a great number of apparent type paths is detrimental to the practical value of the theory of types in forecasting. If only a few storms go to make a type, wherein is there any advantage in having "types?" A "type" stands for something striking—something distinctly noticeable. It is almost impossible to recognize a storm as belonging to a given type if there are only ten or twenty such storms in the course of ten years. If there be types which make their appearance only during some years and not during others, this would still further increase the difficulty of attempting to de-

[3] Where less than four paths were classified in the preliminaries proportionate weight was assigned them when the final classification by four's was made.

[4] See Monthly Weather Review, November, 1907, Vol. xxxv, p. 516–520. "The winds of the Lake region." Prof. A. J. Henry.

[5] Lehrbuch der Meteorologie, Dr. J. Hann, 1906, 2d Ed. p. 319–322.

[6] Waldo, Elementary Meteorology, p. 284.

clare whether a storm belongs to the intermittent or the regular types. Confusion would be the only result.

A few statements by Pernter[7] are worthy of notice. He says:

> It was by this means demonstrated that there is an extraordinarily great variety of forms of atmospheric pressure distribution; that these, however, can be classified into a certain number of types by having regard to the form as well as to the weather conditions given in these forms. * * *
>
> The knowledge of the weather conditions for every place and for every type of pressure distribution offers the only entirely satisfactory empirical basis for weather predictions; moreover, it is by this knowledge alone that we can hope at some time to discover the fundamental laws of the changes in the weather.

Pernter would be correct if ideal conditions prevailed. If one must depend upon types, he will have to wait a long time to discover the "fundamental laws of the changes in the weather." Had Pernter used the expression "variation of pressure distribution," instead of "type of pressure distribution," then his statement would be true; but presence of a "type" assumes the existence of types, which is the problem to be solved first.

In the United States Weather Bureau leaflet, above referred to as "Explanation of the Weather Map," the following statement is made, accompanying the chart of "mean tracks and average daily movement of storms in the United States:"

> The first impression of a student of the weather maps, as they present their seemingly endless forms and combinations of the temperature and pressure lines, is often one of confusion.
>
> The storms of the United States follow, however, year after year, a series of tracks, not capricious, but related to each other by very well defined laws.

Then, after a detailed account of various possibilities of paths which a storm might assume in crossing the continent, a statement is wisely added, which, however, defeats the hypothesis of type paths:

> The chief difficulty in the art of forecasting is to decide which of these paths will be pursued and the probable rate at which the movement will take place.

This is the problem exactly, "which paths will be pursued and the probable rate of movement." If we had a type, we should certainly know the path which a storm would pursue and the exact conditions attending it at every point; but we know by experience, an experience consisting primarily in failures of forecasts, that a storm very often does not follow an expected path nor does it bring about hoped-for conditions, but quite often does just the reverse of what is forecast; sometimes it remains stationary for several days; at times it becomes intensified and moves on with great velocity; again it weakens and moves more slowly; often it apparently splits in two or dissipates entirely.

The eccentricities of storms are well illustrated by many sets of weather maps. Those for the period of November 28 to December 3, 1907, show very nicely the irregular movements of storm areas—the stationary high in the West, a series of swiftly moving lows about the high and of course moving from west to east, a local development of a low in the Mississippi Valley and the movement of the high in the West after having been stationary for six days.

This series of maps and forecasts shows that even the expert forecaster may often be completely at sea, and that it must be misleading to say that—

> By preserving the weather charts each day and noting the movements of the highs and the lows any intelligent person can make an accurate forecast for himself, always remembering that the lows as they drift toward him from the west bring warm weather and sometimes rain or snow, and that as they pass his place of observation the highs following in the tracks of the lows will bring cooler and probably fair weather.[8]

If the distinguished author means that a truly accurate forecast can be made so easily as this, the statement is quite optimistic. It does not require a great deal of study to convince one that under present conditions it is no easy task to forecast with accuracy. The writer here quoted has probably forgotten that it is his long experience which makes forecasting seem easy.

Considering then:

1. What a type storm is;
2. The number of apparent types;
3. The lack of ideal conditions;
4. The presence of local influences;
5. The results of experience in forecasting;

I feel thoroly convinced that there is no type storm; that the type storm as a basis for forecasting must be discarded if we hope ever to arrive at an era of accurate forecasting; that a more thoro study of local influences must be made.

[7] Monthly Weather Review, December, 1903, vol. xxxi, p. 579, 580.
[8] Nat. Geog. Mag., March, 1907.

THE PRESENT AND FUTURE STATE OF MARITIME METEOROLOGY.

By H. HERGESELL, Director of the Meteorological Service of Alsace-Lorraine.
[Translated from the German version in Gaea, August, 1906, p. 480–486.]

By the term "maritime meteorology" I understand the science that has to do with the processes occurring in that part of the atmosphere lying over the sea. The distinction between the oceanic and continental portions of the atmosphere is not only logical but also requisite, for the reason that most meteorological processes are conditioned not merely by direct solar radiation, but also by the thermal interrelations of the atmosphere with the liquid or solid surface of the earth.

The earth's surface exercises so great an influence on the diurnal variation of temperature, the distribution of water vapor, and the occurrence of convectional currents that we can understand these phenomena only by taking into account the sources of heat which this surface offers. As to its thermal action, the surface of the sea is essentially different from that of the land. The land surface receives a certain quantity of heat during the day, and loses it again at night by radiation, so that a rapid alternation takes place and the heat does not penetrate deep into the ground. The solar rays are less readily absorbed by the water surface than by the land, but they penetrate deeper. For this reason, and also on account of the difference in specific heats, the temperature of the water changes less than that of the land, altho the quantity of heat absorbed is decidedly greater. Moreover, the surface temperature of the sea water falls but little, relatively, at night, since the water, as it cools, is immediately replaced by warmer water from the lower strata. This essential difference in behavior between sea and land fully justifies the distinction between maritime and continental meteorology. While our knowledge of the latter has made great progress, our knowledge of the former has made but little; a fact easily explained by the difference in the conditions of observation. Over the land surfaces whereon we dwell, and particularly in civilized countries, meteorological studies are easily carried on; they are, in fact, to a certain extent forced upon us. We have known for a long time, and with considerable accuracy, the laws which govern meteorological processes over dry land; tho, to be sure, our modern methods of investigation have been arrived at but gradually. We began with observations at the earth's surface, then erected mountain observatories, and finally penetrated to the upper, free atmosphere, with the help of kites and balloons.

In the domain of maritime meteorology work has been much less active. Its history is bound up with that of the great oceanographic expeditions, among which the *Challenger* expedition, the scientific voyages of the Prince of Monaco, and the cruises of the *Gazelle* and the *Valdivia* take first rank. The meteorological investigations which these expeditions carried on were, moreover, limited to the lower strata of the atmosphere; only very recently, thanks to the initiative of the Prince of Monaco, has the study of the upper air been taken in hand. We should not, therefore, be surprised that our

knowledge of maritime meteorology still shows great gaps, and above all in regard to the fundamental phenomena of the atmospheric circulation. If a certain stagnation in meteorology was to be observed a few years back, it is to be ascribed to just these gaps, the great importance of which a glance at the map will readily show.

The meteorology of the land relates to four-tenths of the earth's surface, the other six-tenths of its surface being covered by the sea. Hence, we must feel all the more indebted to the Prince of Monaco for having been the first to undertake the study of the upper air strata over the sea. Over the sea as well as over the land it is the upper regions of the free atmosphere whose study is the most important, since it is there that the great currents of the general circulation have their origin, which carry the air from the equator to the poles and back to the equator. I will first say a word regarding the great problems of the general circulation of the atmosphere—problems the study of which we have already begun with the first ascensions from the *Princess Alice*.

It is indubitable that the heating effect of the sun reaches its maximum at the equator. There the air, warmed by solar radiation, rises to great heights, whereby it loses a greater or less part of its aqueous vapor, and then flows off above toward the poles. The air lying to the north and south flows in to restore the equilibrium of the atmosphere, and thus arise the air currents known as "trade winds." In our expedition of last year (1905) we studied the mechanism of this circulation in its general features, and have published our results. The second problem, no less important, relates to the method and means whereby the movement of the ascending air in the vicinity of the equator is accomplished, and the directions taken by this mass of air in the upper strata. The ascending movement takes place probably in the regions of calms in the vicinity of the equator, and can only be studied with the aid of kites, or still better, in view of the relative sluggishness of the air, with sounding balloons. According to the reports of many observers, the air in the region of the equatorial calms is often cloudless, and only sounding balloons can give trustworthy indications of the direction of the air currents in the upper regions of the atmosphere.

The experiments that were carried on over the Mediterranean in April, 1905, have proven that such ascents of sounding balloons are quite easily made. In fact, in the light of the experiments already made, we may conclude that under favorable circumstances it will be possible to observe with these balloons up to altitudes of 14,000 meters and over. The summer and the early autumn are the most favorable seasons for experiments of this kind in the equatorial regions, for then the calm belt extends far to the north and can be reached even with a vessel having but a limited radius of action.

From the study of the calm belt at the equatorial limit of the trade wind we naturally proceed to a study of the region of calms north of the trade wind; i. e., the region of high pressure and feeble air movement that we meet with at about 35° latitude. Here again we must make use of kites and sounding balloons, and we must make every effort to raise the latter to the greatest possible altitudes. For the question is to determine whether there exists a closed circulation of air between the equator and the regions of calms lying north and south of the Tropics, or whether the general circulation of the atmosphere also embraces the circumpolar and polar regions.

Ascents of sounding balloons over the land have proven the existence of a warm stratum of air at an altitude of about 11 kilometers. At that altitude the decrease of temperature with ascent ceases more or less abruptly, to be succeeded by a rise of temperature at higher altitudes for several kilometers upward. This zone of temperature inversion with altitude probably bears some intimate relation to the general circulation, and it appears to be a matter of great importance to determine its exact situation over the sea. Such investigations require the use of sounding balloons, and our experiments have shown that this is practicable under certain conditions. We might also employ a mixt method, which, theoretically at least, holds out prospects of the most complete success. In this method a theodolite must be set up on land (on some island), and with it the flight of the balloon may be followed until it has reached the earth. By measurements of the apparent (i. e., angular) altitude and azimuth of the balloon, together with its vertical velocity, the place of its descent could be determined with sufficient accuracy to enable the ship to find it. This method of sighting has been employed repeatedly at Strassburg, and has given satisfactory results. On the sea its success would be even more probable, for the ship could follow the balloon from the beginning of its ascent, and be kept informed of the direction of its flight by means of wireless telegraphy. The ascent of a sounding balloon to 15 or 16 kilometers altitude and its subsequent descent requires only about ninety minutes, so that the horizontal distance attained in its flight can never be very considerable. By such means the important stratum of the temperature inversion (the "inversion zone") might be studied very successfully in all latitudes. Morever the method of "sighting" the balloons by means of theodolites which we have just explained would enable us to determine with accuracy the direction and velocity of the air currents at every altitude. By this means the great problems of the atmospheric circulation could be solved; for the self-registering instruments of the sounding balloons show the temperature and humidity of all the air strata thru which they pass. A single successful ascent of this kind would, at the present time, possess the highest scientific value.

I now turn to the investigations that will need to be carried out in the polar regions, and that are no less important than the work in the region of calms, for here, also, we have to do with the important question of the general circulation.

According to the observations in the lower strata of the atmosphere there appears to be a general movement of the air toward the lower latitudes (i. e., equatorward). We have grounds, however, for assuming that a contrary condition of things prevails in the upper regions of the atmosphere. Kite and balloon observations are called on to throw new light on the circulation at these altitudes. It would be of still greater interest, however, to get temperature readings from the various strata up to the upper limit of the inversion zone, since its altitude must stand in intimate relation with the general circulation of air between equator and pole. If we find that this upper inversion zone exists in the polar regions—and I have no doubt that we shall[1]—then the simple determination of its height above the ground would give the solution of a whole series of problems in the mechanics of the atmosphere. The ascensions of sounding balloons that have been made at St. Petersburg justify the suspicion that the relatively warm upper layer of air [the isothermal zone or inversion stratum] will be found at altitudes in the atmosphere lower under high latitudes than at lower latitudes. The exact determination of these altitudes should constitute one of the principal aims of maritime meteorology.

Aside from these more general questions there are a great many problems peculiar to maritime meteorology that have a more local character. First of all, I would mention the study of certain peculiar winds, especially the monsoons. These convectional currents with annual period arise on nearly all continental coasts in tropical regions, and are due to the differences in temperature [of the air] over the land and sea. We are here concerned with determining their altitudes and

[1] This prediction has been justified by the results of the balloon observations at Kiruna, Lapland, taken in 1907 under the direction of Teisserenc de Bort—*C. F. T.*

the times at which the movements begin at the different levels of the atmosphere. Such studies may lay claim to great practical as well as scientific interest, for every one knows how important a rôle is played by the monsoons and their attendant phenomena in the welfare of the inhabitants of India. Furthermore, the study of the monsoons of the Indian Ocean is intimately connected with that of the trade winds in the same region, for the northeast monsoon, which blows in winter, is nothing else than the regular trade.

In the neighborhood of the Canary Islands we meet with land and sea breezes having the character of foehns. Similar winds must occur on all coasts, and it would be productive of interesting results to study these phenomena with the aid of kites. In this connection should also be mentioned the mistral and the sirocco of the Mediterranean and the bora of the Adriatic.

Besides these special problems, which are exceedingly numerous in maritime meteorology, it is important to undertake the study of the atmosphere over the sea from a general point of view, and to make such investigations as frequently as possible. The great questions as to the circulation of the air in cyclones and anticyclones, the formation of these areas of low and high pressure, their transformations and movements of translation must be studied on the sea just as on the land. Especially will the study of isobaric surfaces over the ocean lead us directly to a knowledge of the mechanical conditions of their existence, for the principal source of complication in this problem—viz, the effect of the very irregular surface of the earth—is lacking over the ocean.

The use of sounding balloons is to be recommended for investigations of this sort, and the vicinity of the Azores may be pointed out as especially suitable for the purpose. Here we find ourselves within one of what Teisserenc de Bort and Hildebrandsson have named the "action centers" of the atmosphere. In the neighborhood of the Azores we often meet with small depressions, which originate in the vicinity of these islands, and, as they deepen, move off to the westward. The study of the development and progress of these small depressions would be very instructive.

There is one final point that I wish to refer to. We know that the temperature of ocean currents has a considerable influence on the temperature of the air over them. In proof of this we may refer to the isothermal charts of Norway, in which the isotherms are seen to be pushed far to the north in consequence of the influence of the Gulf Stream.[2] It would be of great interest to know to what height in the atmosphere this influence makes itself felt. A few kite ascensions would suffice to throw light upon this question. Furthermore, similar influences are met with not only in Norway, but also, for example, on the west coast of Africa, where cold water from the depths of the ocean comes to the surface and lowers the temperature of the air.

It is not possible to discuss here in detail all the questions in maritime meteorology that ought to be studied; my object will have been attained if I have made clear the importance of the problems that I have mentioned. The reader can not fail to observe that among these problems there are some that will require for their investigation a rather long period of time. Such investigations can hardly be undertaken except by the navies of the different countries and the great companies of the merchant marine. In this connection I may state with pleasure and gratitude that His Highness the Prince of Monaco has succeeded in awakening in his Majesty the German Emperor an interest in these questions, and that the cooperation of the German navy appears to be assured. Moreover I am happy to announce that several large German marine companies have exprest a wish to take part in these important investigations. Yet, however important and desirable all this cooperation may be, the fact should be emphasized that a certain number of problems above referred to can be solved only after very special preparations have been made. A swift vessel is indispensable, and one that will lay its course entirely in accordance with the exigencies of the problem in hand, and that has, moreover, an equipment specially adapted to the work. All these desiderata can only be realized in a regularly organized expedition, having for its sole object investigations in maritime meteorology; and the history of modern science permits us to hope that such an undertaking will actually come about. The great civilized nations have expended millions to probe the mysteries of the poles; but the problems that await solution in the ice-cold regions of the upper air are no less important than those hidden beneath the polar ice. There can be no doubt that a voyage around the world having for its sole task the unriddling of the still unexplored mysteries of the upper atmosphere would achieve as much success and applause in the scientific world as the exploration of the unknown regions of the poles.

[2] The drift of the surface waters due to the southwest winds of this region is sometimes erroneously spoken of as an extension of the Gulf Stream.—*C. A.*

The above paper was originally published in 1905 in the Bulletin du Musée Océanographique de Monaco, No. 44. The original (in French) not being at hand, the foregoing translation has been made from a German version published in Gaea, 42. Jahrgang, August, 1906.

The desiderata set forth above are being rapidly fulfilled. Doctor Hergesell's earlier expeditions on the *Princess Alice*, on the Mediterranean and the Atlantic, were made in 1904 and 1905. In 1906 he made observations over the Arctic Ocean. Most noteworthy among the achievements of 1906 was the expedition sent out by Messrs. Rotch and Teisserenc de Bort, on the *Otaria*, which proved the existence of the return-trades; i. e., winds having a poleward component blowing above the level of the trade winds. The latter were found to have an average depth of only 1,000 meters, and the return-trades were encountered at a height of from 1,800 to 3,000 meters. The same expedition revealed the fact that the temperature at great heights above the thermal equator is lower than it is at the same heights in temperate regions, owing to the absence of an "isothermal zone." In 1906, also, the survey-ship *Planet*, of the German Navy, sailed from Kiel on a long voyage to the South Seas, in the course of which she made a series of upper-air observations over the Atlantic, Indian, and Pacific oceans. Several successful kite observations were made by Doctor Linke in Samoa.

In the summer of 1907 occurred the first "international week" of simultaneous ascents of kites and balloons in all parts of the world (July 22–27). In addition to a great number of observations at land stations, the French cruiser *Forbin* observed with sounding balloons in the neighborhood of the Azores; the Italian man-of-war *Fulmine*, having on board Doctor Palazzo, director of the Italian meteorological service, made observations over the Mediterranean; Russian vessels observed over the Gulf of Finland and the China Sea; the German Navy participated with two vessels—the *Planet*, in the South Pacific, and the *Möwe*, in the Atlantic between Iceland and Norway; a private expedition under Hewald and Hildebrandt made ascents between Iceland and the British Isles; the *Otaria* was again at work in the vicinity of the Azores; and Doctor Hergesell himself accompanied yet another expedition of H. H. the Prince of Monaco, which carried on observations in Spitzbergen.

Another "international week" is planned for the summer of 1908. This time it is intended to concentrate all efforts upon the equatorial regions, which will be covered by as many ascents as possible both by land and by sea. The German Navy has planned ascents off the west coast of Africa

and in the Pacific Ocean north of the equator, and there is a prospect that the French Navy will carry on work in the French West Indies. Other maritime nations, including the United States, have been invited to join in this important campaign. This international ocean work offers a fine opportunity for wealthy American owners of fine pleasure yachts to devote a little attention to the study of the atmosphere over the ocean.—*C. F. T.*

ABSTRACTS OF RUSSIAN METEOROLOGICAL MEMOIRS.

By Prof. ALEXANDER VOEIKOV. Dated St. Petersburg, December, 1907.

As the Travaux du Cabinet de Geógraphie Physique de l'Université Imperial de St. Petersburg, premier fascicule (Work of the Department of Physical Geography of the Imperial University of St. Petersburg) is out of print, I give herewith a short abstract of the articles therein; following this is a summary of a recent article by Chipchinskii and a note by myself.

I. *Temperature and precipitation of eastern Siberia. 32 pp. Ivitskii.*

I have given an abstract of these temperatures in Meteorologische Zeitschrift, 1900, p. 116, to which I here refer, and give now only a table of precipitation. (See Table 1.)

Everywhere, except in Kamtchatka, the west shore of the Sea of Okhotsk, and Sakhalin, the summer rains predominate enormously. In the two latter regions the rains of the monsoon of eastern Asia come but a little later, as in July the sea is yet too cold to yield much vapor. The same is partly the case in Vladivostok and St. Olga. Kamtchatka is entirely out of the region of the monsoon, and Petropavlosky has about the climate of northern Newfoundland, being very humid and rich in rain or snow during the whole year. The first six places of the table are in the region of the Asiatic anticyclone of winter, when calms largely prevail. Besides, the winter is so cold here that heavy precipitation is impossible. In summer the temperature is high for the latitude, vapor of water is abundant, and frequent cyclones are favorable to precipitation. So here also summer rains prevail enormously, tho the country is out of the region of the Asiatic monsoon, which only reaches to about 60° north latitude on the west shore of the Sea of Okhotsk.

TABLE 1.—*Precipitation in eastern Siberia.*

N. latitude.	E. longitude.	Height.	Name.*	Spring.	Summer.	Fall.	Winter.	Year.	Maximum. Amount.	Maximum. Month.
°	°	*Met's*		mm.	mm.	mm.	mm.	mm.	mm.	
62.0	129.7	100	Yakutsk	38	144	63	29	273	56	VIII
53.2	114.3	537	Blagovestchensk Priisk	51	146	81	51	329	57	VII
52.3	104.3	491	Irkutsk	56	192	75	46	369	73	VII
51.8	107.6	521	Verkhneudinsk	21	130	32	13	196	68	VII
50.4	106.4	782	Kiakhta	27	186	42	8	264	82	VII
51.3	119.6	657	Nerchinski Zavod	48	285	69	8	409	110	VIII
50.2	127.6	110	Blagovestchensk	84	327	101	4	515	136	VIII
48.5	135.1	77	Khabarovsk	107	262	105	25	499	140	VIII
52.4	134.1	915	Sofiiski Priisk	53	388	109	13	563	164	VII
53.1	140.7	35	Nicolaievsk	87	174	141	49	451	80	VIII
56.5	138.3	10	Ajan †	74	471	368	43	957	234	VIII
56.5	158.8	16	Petropavlovskii Kamtchatka	314	189	399	292	1193	170	XI
50.8	142.1	7	Alexandrovskii, Sakhalin	89	193	227	90	599	98	IX
50.8	142.9	125	Rykovskoye, Sakhalin	80	215	197	58	557	96	IX
46.6	148.8	26	Karsakovsky Post, Sakhalin	90	149	132	48	420	66	IX
43.7	135.3	45	St. Olga	160	379	270	60	859	190	VIII
43.1	131.9	17	Vladivostok	69	202	122	13	408	96	VIII

* The spellings of the atlases of the Encyclopedia Britannica and the Century Dictionary are adopted.
† At or near sea shore.

II. *Climate of Batum. 17 pp. Moskalskii.*

The following table gives the principal elements of the climate of Batum: (latitude 41.5° N. longitude 41.5° E.).

TABLE 2.

	Mean temperature.	Relative humidity.	Amount of cloud.	Precipitation. Amount.	Precipitation. No. of days with 40mm. or more.
	(1) °C.	(2) %	(3) *Tenths.*	*mm.*	(4)
I	6.3	76	5.6	251	1.2
II	5.9	79	6.1	188	0.8
III	8.3	81	6.5	154	0.4
IV	11.1	82	6.2	128	0.3
V	15.7	83	6.0	72	0.1
VI	20.3	81	4.7	143	0.1
VII	23.1	80	5.2	154	1.1
VIII	25.7	81	5.2	226	2.4
IX	20.4	82	4.7	314	2.6
X	17.0	81	4.2	205	2.1
XI	12.2	81	5.5	321	2.9
XII	9.6	75	5.5	253	1.7
Year	14.5	80	5.2	2408	16.4

(1) 15 years 1882–1896. Mean of observation at 7, 13, and 21 hours.
(2) 13 years 1884–1896. Same hours.
(3) 15 years 1882–86. Same hours.
(4) 15 years 1882–86.
The greatest quantity of rain in one day was 261 mm. in August, 1882.

The humidity of the air is great, especially in the warmer months, the rains very heavy, by far the heaviest of all on the shores of the Mediterranean and the seas opening into it. The contrast is very great with eastern trans-Caucasia and the shores of the Mediterranean where the summer is nearly rainless. Great quantities on one day are frequent at Batum, and these heavy rains often fall at night, without thunder and lightning, and with high barometric pressure. Especially is this the case from August to November. The high temperature, great humidity of the air, and abundant rains are favorable to a rank plant growth. In this respect the vegetation resembles that of the dampest parts of the Tropics, but the genera of plants are the same as in central Europe. The air is dryest in winter, when land winds predominate somewhat.

III. *The winds of Batum. Novitskii.*

The mountainous country around the city of Batum deflects the winds from their original course, and is thus unfavorable to a consideration of the relation of barometric gradients to winds. The sea winds are more frequent in the spring and summer, the land winds in winter. At all seasons, with partial exception of winter, there is a very marked daily period in the winds. In the middle of the day they come mostly from the sea; calms are not frequent, they predominate at the hours 7 and 21 local meridian time. Observations in the middle of the night would have shown a greater percentage of land winds than at these two hours.

TABLE 3.—*Percentage of winds at Batum.*

FOR FIFTEEN YEARS, 1882–1896.

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calms.
Spring	7.3	5.0	13.3	7.5	7.6	23.9	5.4	8.5	16.1
Summer	4.1	2.1	13.7	6.2	8.1	25.6	10.1	11.6	18.3
Fall	6.1	6.2	15.7	9.5	11.1	16.6	7.6	6.1	13.1
Winter	6.3	8.4	22.5	14.4	10.3	19.9	3.5	3.8	13.9

FOR 7 A. M., 2 P. M., AND 9 P. M. FOR TWO YEARS, 1895–96.

Seven hours	2.1	8.5	8.4	5.9	5.9	11.3	2.1	1.7	5.4
Thirteen hours	7.6	2.8	1.8	4.2	5.1	19.7	19.9	24.8	14.1
Twenty-one hours	1.5	2.2	4.5	4.5	3.5	11.1	2.8	0.7	69.2

The land winds, when strong, have the character of foehns; they bring a very high temperature (up to over 28° C.) in March and October and over 25° in December and a great dryness of the air, which are in great contrast to the moderate temperature and great humidity generally experienced. When such winds continue two to three days without intermission the vegetation suffers greatly. I give the following examples of foehn days:

TABLE 4.

Date.	Hour.	Temperature.	Relative humidity.	Wind.	
		°C.	%	Dir.	Vel.
1883.					
December 25	21	19.5	30	e.	6
26	7	18.9	49	e.	6
26	13	16.1	81	e.	2
1895.					
December 9	7	20.9	39	se.	8
9	13	25.3	29	se.	6
9	21	21.5	37	se.	6
10	7	14.3	86	sw.	8
1888.					
October 22	7	28.5	30	se.	9
22	13	26.9	37	se.	10
22	21	24.1	51	s.	6
23	7	15.3	96	sw.	6
1887.					
March 18	7	19.7	29	e.	2
18	13	28.1	24	se.	4

IV. *Climates of the heights of western Europe.* *A. Voeikov.*

As the memoir is rather long, I send a copy of it to the Library of the Weather Bureau and give no abstract of it. I need only state that the conditions at the summits of the Eiffel and Strasburg towers and at the French mountain stations were compared with those at the respective bases as to temperature, humidity of the air, and force of the wind. Some other mountain regions are compared with the mountains of France.

V. *Comparison of the intensity of the solar radiation at St. Petersburg and at Pavlovsk.* *W. Chipchinskii.*

(Work of the Department of Physical Geography of the Imperial University of St. Petersburg; 3d part, pp. 44–68; St. Petersburg, 1906).

The Observatory of Pavlovsk is 30 kilometers south of St. Petersburg, at the end of a large park, with very few houses in the vicinity. The nearest factories are at a distance of 8 kilometers. There is very little dust and smoke. The Imperial Central Physical Observatory at St. Petersburg is at the southwest extremity of the city, and surrounded by factories making use of bituminous coal. The conditions for actinometrical observations are thus excellent in the former place and bad in the latter. The method of observation gives strictly comparable results; at both places the current observations are made with the relative actinometers of Chwolson, and both instruments are generally compared monthly with the absolute Ångström-Chwolson pyrheliometer at Pavlovsk.[1]

[1] Insolation is the exposure, in general, to sunshine, either at the sea level or at any height in the atmosphere; the term is not restricted to a surface at the upper limit of the atmosphere, nor to plane or curved curved surfaces.

The duration of sunshine in time, its quality as to wave-length, and its intensity in calories per unit of time, per unit of surface, are distinct aspects of insolation.

The intensity per unit area on horizontal or inclined surfaces is often needed in meteorology, but the intensity for normal incidence on a unit surface at the station is the quantity measured in actinometry, and is that here given as θ_1 at Pavlovsk, and θ_2 at St. Petersburg.

From the local intensities of insolation observed at different hours during very clear days we compute the influence of the atmosphere as to absorption and diffuse reflection, and can thus infer approximately the intensity of insolation outside the atmosphere before any loss takes place; this final result is the so-called solar constant, or constant of solar radiation for a normal surface at the mean distance of the earth from the sun.

The rarity of fine, clear weather appropriate for actinometric work is illustrated by the following list of the number of days on which simultaneous observations were secured at St. Petersburg and at Pavlovsk:

1894.....12 days.	1898..... 6 days.	1902..... 5 days.
1895..... 7 days.	1899.. ... 9 days.	1903.....17 days.
1896..... 7 days.	1900..... 7 days.	
1897..... 9 days.	1901.....10 days.	

A total of 89 days in 10 years. But the number of days on which the sky is equally fine during mornings and evenings, or with low sun and high sun, is far less than the above figures would suggest; so that determinations of the solar constant, reliable to within 5 per cent of its own value, have as yet been only very rarely attained. A few special mountain stations seem to be the only places appropriate for this work.—EDITOR.

The author found 62 days in which the observations were made within 10 minutes of time of each other, and the mean result is $\theta_1=1.20$ calories, $\theta_2=1.03$ calories, $k=1.17$; where θ_1 is the result at Pavlovsk, θ_2 at St. Petersburg, both in small calories per minute, and $k=\theta_1/\theta_2$ is the ratio of these.

Again, 88 observations at Pavlovsk and 92 at St. Petersburg, made simultaneously, or within 3 minutes of time, and on 44 days, gave the following means: $\theta_1=1.20$ calories, $\theta_2=1.06$ calories, $k=1.13$. Considering only the observations made when the sky was cloudless at both places, the means for 14 days are $\theta_1=1.27$ calories, $\theta_2=1.15$ calories, $k=1.10$. Hence k is considerably smaller in these cases, because the not infrequent days with haze at St. Petersburg (11 days in this case) have been excluded.

The author gives also the mean values for different directions of the wind. The buildings of the city extend continuously from the Central Physical Observatory 4 kilometers northward, 7 kilometers eastward, 3 kilometers southward, and 2 kilometers westward.

The resulting actinometric wind roses for the two stations are:

TABLE 5.

Winds.	θ_1	θ_2	k	Number of days.
North....	1.11	0.87	1.28	5
East.....	1.21	0.96	1.26	17
South....	1.23	1.08	1.14	15
West.....	1.20	1.09	1.10	25

Except for north winds, which seldom occurred, the means are such as would be expected, greatest at St. Petersburg with west winds and smallest with east winds.

In thirteen cases θ_2 was greater than θ_1, that is to say, solar radiation was more intense in the great city; of these cases ten were with west winds and three with south winds.

As to the influence of the seasons Chipchinskii finds the averages given in Table 6,

TABLE 6.

Season.	θ_1	θ_2	k	Number of days.
Winter...	1.06	0.90	1.18	10
Spring...	1.30	1.13	1.15	30
Summer .	1.16	1.08	1.07	15
Fall.....	1.06	0.73	1.45	7

The greatest number of days favorable for actinometrical observations and the clearest atmosphere on such days is found in spring, especially in early spring, and the worst conditions in the autumn.

The maximum values at Pavlovsk for each month, and the accompanying conditions of temperature, wind, and humidity, as selected from the whole record for ten years, are given in Table 7.

TABLE 7.

Date, new style.	Month.	Local mean time.	Maximum. θ_1	Temperature of air.	Vapor pressure. Absolute humidity.	Wind.		Sky and clouds.
						Dir.	Vel.	
		h. m.		°C.	mm.		m. p. s.	
1898, January 29.	I	11 40	1.16	— 8.9	1.1	nw.	7	0
1899, February 28.	II	9 38	1.31	— 9.1	1.7	wsw.	2	2 A.-Cu.
1898, March 29....	III	10 9	1.42	— 4.6	2.0	sw.	4	†Ci.
1898, April 24.....	IV	10 53	1.45	9.6	2.7	sw.	2	1 Ci.
1901, May 1.....	V	11 37	1.45	10.2	3.0	esc.	3	0
1899, June 21.....	VI	*14 26	1.42	12.8	6.0	ne.	7	†Ci.
1899, July 12.....	VII	10 16	1.33	21.3	10.6	se.	3	†Fr.-Cu.,Cu.
1895, August 16...	VIII	11 14	1.34	13.2	6.4	ne.	10	0
1897, September 18	IX	10 54	1.35	12.4	2.3	nne.	2	†A.-Cu.
1898, October 18 ..	X	11 28	1.33	— 6.7	2.2	ene.	4	0
1894, November 9.	XI	11 1	1.14	— 9.4	1.5	ese.	2	0
1896, December 7.	XII	12 1	0.98	—16.9	0.8	ssw.	2	0

*2 p. m. † Less than one-tenth.

Thus we have three months (November to January) of low

maxima, five months (February and July to October) of moderate, and four (March to June) of high maxima. The months of high absolute humidity, July and August, are unfavorable to great intensity of insolation. The maxima of intensity are higher not only in the spring months, but also in September, and the absolute maximum of October is equal to that of July, but how different are the conditions of the lower atmosphere! In October the temperature is —6.7° C. and absolute humidity 2.2 mm.; in July the temperature is 21.3° C. and absolute humidity 10.6 mm.

During ten months out of twelve the absolute maxima were observed in the forenoon, a fact observed also elsewhere, apparently due to the fact that in the morning there is less aqueous vapor and generally also less dust or haze than in the afternoon.

At the end of this memoir the author gives in detail, for both stations, all the corresponding observations of radiation, cloud, and wind. The maximum radiation of each month, shown in the author's tables in bold-face type, is given in the accompanying Table 7, in plain figures, in column under head of "Maximum."

THE STUDY OF EVAPORATION.

By Prof. A. VOEIKOV. Dated St. Petersburg, December, 1907.

I was much interested in Professor Bigelow's paper "on the Salton Sea and evaporation."[1] Such another occasion is not to be expected soon, and the study intrusted to a man of the knowledge and ability of Professor Bigelow will be of immense benefit to science.

My present remarks apply to the comparison of the different formulas for evaporation in which the velocity of the wind is introduced. Professor Bigelow, by introducing the same values of temperature, humidity, and wind, finds that the results vary more than in the relation of 2:1 (Stelling 0.3495, Abassia 0.1337). I think the principal cause of the discrepancy between these empirical formulas is that the wind velocity was not observed at the same place where the evaporating basin or dish is situated, the anemometer being placed much higher, on the top of a building or on a tower.

The better the anemometers are placed for the needs of general meteorology—that is to say, the freer is the access of air and the less the retardation by friction, by so much the less will these wind velocities agree with those at the surface of the evaporation basin or dish. Then, if the evaporation is measured from a large tank or basin in the open air, the access of the wind will be freer than to small evaporation dishes placed, as they often are, in screens whose walls impede the access of air; but, on the other hand, the humidity of the air will be greater over the surface of a larger body of water, owing to the diffusion of the greater quantity of evaporated water.

The examples in Table 1 show a great discrepancy in the rate of evaporation, while the wind velocity, temperature, and humidity of the air are nearly the same. The evaporometer and its exposure in the screen were the same. The wind velocity is given approximately by Wild's wind vane, with heavy inclined pendulum plane.

TABLE 1.

Month.	Pinsk, 52° N., 26° W.				Vasilivichi, 52.3° N., 29.6° W.			
	Evaporation.	Temperature.	Relative humidity.	Vapor tension.	Evaporation.	Temperature.	Relative humidity.	Vapor tension.
1897.	mm.	°C.	%	mm.	mm.	°C.	%	mm.
June	71.4	18.7	63	3.5	96.6	18.3	69	2.3
July	65.2	19.9	76	3.0	94.7	20.1	73	2.8
August	65.8	19.4	73	3.1	96.5	19.0	74	3.1
September	34.5	12.9	81	2.3	52.9	12.9	80	2.3

[1] Monthly Weather Review for July, 1907.

Both places are in nearly the same latitude and distant by about 100 kilometers. At Pinsk there is a great expanse of river and marsh to the south and west. So the winds have freer access than at Vasilivichi, where forests impede them more. But at the screen where the evaporators are placed there is a rather thick growth of trees at Pinsk, while at Vasilivichi there is no growth of trees in the vicinity of the screen.

If empirical formulas were deduced from the observations at these two places, their coefficients would be different, those from the Pinsk observations would be such as to give smaller values for the same wind velocity, and those from the Vasilivichi observations greater values.

THE EVAPORATING POWER OF THE AIR AT THE NEW YORK BOTANICAL GARDEN.

By C. STUART GAGER. From the Journal of New York Botanical Garden, December, 1907.

In May, 1900, three meteorological stations were established in the garden.[1] Station 1, located in the herbaceous garden, was equipped with a standard rain gage, a thermograph, and a set of maximum and minimum thermometers. Station 2 was on a low ridge in the center of the hemlock forest, and station 3 in the central portion of the elevated plain of the fruticetum. The last two stations were equipped with thermographs only.

Late in September, 1904, these three stations were abandoned.[2] The catchment basin of the rain gage was installed on the roof of the museum building over the physiological laboratory, and, by means of a lead pipe extending down thru one of the supporting pillars, it was connected with the gage at the base of the pillar, inside the laboratory. The amount of precipitation recorded at the new station was found to be approximately the same as at the old one. The thermometers and thermographs were all transferred to a shelter house located within the experiment garden, near the propagating houses, on the eastern border of the garden.

Until June, 1907, the meteorological records at the garden include only the dates and amounts of precipitation, and the temperature of the air and that of the soil at two depths. The amount of precipitation, however, is not an index of the amount of water available to vegetation. Part of the meteoric water drains away thru the soil before it is used, while a portion of it evaporates from the surface of the soil into the air. It is the ratio between annual precipitation and evaporation that chiefly determines how nearly a given region approaches to either a swamp or a desert. In a swamp evaporation is less than precipitation, while in a desert the reverse is true.

It is a well-known fact that the rate of evaporation from a given area depends upon the relative humidity of the surrounding air. Relative humidity, in turn, varies with the temperature of the air and with the environment. Thus, for a given air temperature, the rate of evaporation from a given water surface will vary with the area of the surface and with the depth of the water, and the rate of evaporation from moist substances will be modified by the nature of the substance, and with the amount of moisture it contains. Thus, for example, water will evaporate more rapidly from one square foot of water surface than from two square feet, and more rapidly from one square foot with a depth of, say, one quarter of an inch, than it will from the same area over a depth of one foot. Also the same amount of water will evaporate at different rates from clay soil and from sand soil. Shrubbery and foliage tend in several ways to increase the relative humidity of the surrounding air, thus retarding evaporation.

The experiments described in this paper form part of a more extended investigation, inaugurated by Dr. Burton E. Livingston, of the Desert Botanical Laboratory, of the Carnegie Institution, at Tucson, Arizona. Evaporimeters of uni-

[1] Journal N. Y. Botanical Garden, vol. 1, p. 76, 1900.
[2] Journal N. Y. Botanical Garden, vol. 5, p. 211, 1904.

form pattern, and standardized, have been distributed to some twenty-seven stations in the United States, ranging from Orono, Maine, on the east, to California on the west, and from Bozeman, Montana, on the north, to Gainesville, Florida, on the south, covering a wide range of altitude and of nearness to large bodies of water. Of these instruments, those received at the garden were Nos. 28, 30, and 34. It is hoped by means of the investigation to be able to establish a unit for measuring evaporation.

On the 6th of June, 1907, the evaporimeters were installed at three stations within the garden. These instruments consist of a pint fruit jar tightly corked with a cork stopper soaked in paraffine. Thru the stopper a glass tube extends from the bottom of the jar up and thru a second cork which tightly closes the opening into a porous clay thimble. The glass tube extends to the top of the thimble. For further protection against the entrance of water from without a paraffined piece of cloth was fitted tightly around the glass tube, and extended as a roof over the top of the fruit jar.

The jar was filled with distilled water up to a zero mark, and the porous thimble and the glass tube were also filled with distilled water. Each evaporimeter was sunk into the ground to the level of the top of the fruit jar. As evaporation took place from the surface of the thimble the water rose from the jar up thru the glass tube, thus keeping the thimble full and lowering the surface of the water in the jar. The rate of evaporation varied with the relative humidity of the surrounding air, and the amount was measured by carefully pouring more distilled water into the jar from a graduate until the water surface in the jar rose again to the zero mark. The amount of water necessary to accomplish this was the measure of the amount of evaporation for the given period.

Station 1 (evaporimeter No. 18) was west of the propagating houses on a dry, rocky knoll, covered with only a thin layer (one to two feet) of soil, and well drained. The instrument was shaded on all sides by tall saplings of red cedar and ailanthus, and numerous small herbaceous plants and vines such as smilax rotundifolia and ferns. The surface of the ground was covered with twigs and dead leaves. Station 2 (evaporimeter No. 30) was about fifty feet south of the stable near the eastern border of the garden. The ground is low, poorly drained, and marshy during the spring and other periods of wet weather. The instrument was surrounded with unmoved grassy sod, shaded by a tall sapling of alder on the west, and by tall shrubbery (forsythia, etc.) on the east. Station 3 (evaporimeter No. 34) was about six feet east of the instrument shelter in the experiment garden (fig. 37, omitted). On the north and west was sod, on the east and south cultivated ground, with evening primroses within two feet. The soil here is loamy and well drained.

The photograph (omitted) shows the above-ground portion of the evaporimeter near the tall fence post. Evaporation takes place only from the upper (whiter) part of the porous clay thimble. The top of the fruit jar which is sunk into the ground is covered by the paraffined cloth "roof," thru which the glass tube passes from the jar into the clay thimble.

The instruments were all standardized by Doctor Livingston, so that, after applying the correction for each instrument, the respective readings were strictly comparable, varying only with the external conditions that control evaporation. Readings taken every week on Monday morning from June 6 to October 14, 1907, and standardized by applying the necessary correction constant, are given in the following table.

It has been ascertained by Doctor Livingston that an evaporation of 6.05 cc. from the evaporimeters corresponds to 1 mm. of depth, or, in English units (since it is customary to measure precipitation in inches), 153.67 cc. of evaporation equals 1 inch of depth. For the purpose of ascertaining these data comparisons were made between the evaporation from the evaporimeters and from a chemical water bath, 25.6 inches in diameter, with the water standing 11 cm. deep when the surface is at zero on the scale. "It stands," writes Doctor Livingston, "with the water-surface level with the middle of the evaporimeters to be tested, and about two meters away from them. It is about 15 cm. from the ground to the water level. This level is about 5 mm. below the level of the dish at the beginning of a period, and the vessel is refilled once a day when the readings are made."

Week ending.	No. 28.	No. 30.	No. 34.	Week ending.	No. 28.	No. 30.	No. 34.
June 10, 1907	66	48	.....	Aug. 19, 1907	126	89	188
June 17, 1907	77	48	129	Aug. 26, 1907	105	64	131
June 24, 1907	99	51	147	Sept. 2, 1907	118	85	128
July 1, 1907	60	29	106	Sept. 9, 1907	47	32	41
July 8, 1907	77	47	137	Sept. 16, 1907	74	41	85
July 15, 1907	99	55	129	Sept. 23, 1907	50	27	58
July 22, 1907	60	37	124	Sept. 30, 1907	50	.....	35
July 29, 1907	130	56	185	Oct. 7, 1907	99	32	80
Aug. 5, 1907	98	37	132	Oct. 14, 1907	68	.....	61
Aug. 12, 1907	82	46	142				

The total precipitation registered at the garden from June 10, 1907, to September 23, 1907, was 9.32 inches. This amount will be approximately the same for all three evaporimeter stations.[3] Therefore, taking the difference between the amount of precipitation in inches and the amount of evaporation from the evaporimeters in inches, we have:

For No. 28 (at the propagating house).... 9.32 in. — 8.47 in. = .85 in.
For No. 30 (at the stable)..... 9.32 in. — 4.84 in. = 4.48 in.
For No. 34 (at the experiment garden).... 9.32 in. — 12.10 in. = — 21.42 in.

That is, at the propagating house precipitation was .85 inch in excess of the loss from the evaporimeter; at the swampy region, near the stable, 4.48 inches; while in the experiment garden during the same period the evaporating power of the air was 2.78 inches in excess of the precipitation recorded.

Now in should be kept in mind that the loss of water from the evaporimeters is not a measure of the amount of water lost by the soil thru evaporation, but is *only an index of the evaporating power of the air* for the given station. For the same locality the rate of evaporation from soil and from evaporimeter will materially differ, being less from soil and varying with its nature and condition, as well as with the surroundings above the soil surface.

The purpose of the above data, therefore, is not to give a measure of the amount of precipitation that remains in the soil, or that becomes available to the plants, but, as already emphasized, to give a measure of the evaporating power of the air in different localities. The above record, then, gives *numerical expression* of the fact that, of the three localities studied, the evaporating power of the air is greatest in the experiment garden, least at the swampy area near the stable, and intermediate on the elevated, shaded, and well drained rocky knoll.

RADIUM: ITS PROPERTIES, DISTRIBUTION, AND INFLUENCE ON THE ATMOSPHERE.

By W. W. STRONG. Dated Baltimore, Md., November 12, 1907.

THE RADIOACTIVITY OF RADIUM.

In communicating this memoir to the MONTHLY WEATHER REVIEW the author would remark that while the presence of the radium emanation in the air has not as yet led to any fundamental meteorological discoveries, yet I think it may clear up many points in atmospheric electricity. I believe that the ionization produced by the α particles of the emanation and "radium *C*" plays a considerable rôle in the formation of nuclei for raindrops to condense upon.

Ramsay discovered small quantities of helium, argon, and neon in the air. These may be disintegration products of radium also.

[3] This may be far from true; there should be a gage near and at the level of each evaporimeter.—EDITOR.

On the whole then, I believe that this subject will in the end serve to clear up many outstanding phenomena even if it does not directly aid in predicting the weather.

This summer I was very much surprised to find an enormous (relatively) amount of external radiation during the forenoon—from 8 a. m. until 2 or 3 p. m. This may be due to the expansion of the air in the soil and an increase of emanating power due to the heating by the sunshine, or it may be due a change of the barometric pressure. It is to be noted that thunderstorms usually follow periods when the emanating power of the ground has been quite large. So it is quite possible that the emanation may have a rôle to play, altho not a fundamental one.

Any substance that possesses the power of making a gas become a conductor of electricity by producing in it a greater number of positively and negatively charged carriers of electricity is said to be radioactive. The best known radioactive substance is radium, discovered by the Curies in 1898.

Radium has been found to emit spontaneously and continuously a flight of material particles, projected with an enormous velocity, and also to be the source of radiations similar to X-rays and called γ-rays. The material particles consist of positively charged particles shot out with a velocity approaching that of light. They are readily absorbed by thin sheets of metal foil or by a few centimeters of air, and resemble the canal rays formed in vacuum tubes during electrical discharges. It is found that homogeneous α particles, that is, α particles with the same velocity, cease to ionize the air, to produce photographic action on a sensitive plate or to produce phosphorescence on a screen like zinc sulphide after having gone a certain definite distance from their source. This distance is called the range of the α particle.

If the α particles are traveling in the air under standard conditions of pressure and temperature, then the greatest distance the α particles ionize the gas from the radioactive body will give the range of the α particles in centimeters.

The β particles are found to carry a negative charge and to be the same as the corpuscles found in electrical discharges in vacuum tubes. They carry the same charge as an ion of hydrogen in electrolysis and possess a mass equal to about $\frac{1}{700}$th that of the hydrogen atom. In passing thru matter, they are absorbed according to an exponential law and do not possess a definite range as do the α particles. The β particles are far more penetrating than the α particles and are projected with velocities almost as great as the velocity of light. The α particles produce the greatest amount of ionization, the γ-rays the least. With a thin layer of radioactive matter spread over the two plates, say 5 centimeters apart, it will be found that the relative order of ionization due to α, β, and γ radiations is as 10,000 to 100 to 1, whereas the average penetrating power is inversly proportional to the relative ionization. Photographic action is due almost entirely to the β particles.

Another type of radiation is the δ-rays which consists of slow moving corpuscles with a velocity of 3.3×10^7 centimeters per second. It has been found that the bulk of the ionization produced by the α particles consist of the displacement of the slow moving corpuscles from the atoms of the substance traversed, i. e., of the production of δ-rays. Bragg believes that β particles also produce δ-rays, and that δ-rays produced in various ways and under different physical and chemical conditions all possess the same velocity.

The radioactivity of the radio-elements is not a molecular, but an atomic property and the rate of emission of the radiations depends upon the amount of the element present, and is believed to be unaffected by the application of any known physical or chemical forces. Any product will decay according to the exponential law $N=N_0e^{-\lambda t}$ where N is the number of particles unchanged after a time t, N_0 is the initial number of particles, and λ is the constant of change. Since $dN/dt=-\lambda N$, the rate of change at any time is always proportional to the amount of matter unchanged. This theory has been of enormous service in interpreting radio-active phenomena and in suggesting new lines of work. At present the theory and fact agree. To explain the emission of positively and negatively charged particles, Rutherford and others consider the radio-elements as undergoing spontaneous changes and that the energy of projection of the α and β particles had previously been stored up in the atom as rapid oscillatory or orbital motion. This breaking up of the atom is considered to be accompanied by the production of a series of new substances which have distinct physical and chemical properties. These products are not produced simultaneously but arise in consequence of a succession of changes originating in the radio-element. For instance radium is an element very closely allied in chemical properties to barium. It has a definite spectrum of bright lines similar in many respects to the spectra of the alkaline earths. Now, if a radium compound is dissolved in water and boiled for some time it is found on evaporation that the activity has been diminished by 75 per cent. This loss of activity is due to the escape of the direct decomposition product of radium by the process of boiling. This product is called the emanation and is an inert gas. This gas is extremely radioactive and condenses at —185° C. In respect to its spectrum and absence of any definite chemical properties, it resembles the argon-helium group of inert gases. The emanation is to be considered an unstable gas which breaks down into a nonvolatile type of matter, the disintegration being accompanied by the projection of an α particle. The nonvolatile matter produced from the emanation has been broken up into several products, radium *A*, radium *B*, radium *C*, etc. The rate of breaking up of these products has not been found to be changed by the variation of the physical and chemical conditions under which they exist. For instance, Schuster has found no change in the activity of the emanation when subjected for four days to a pressure of 2,000 atmospheres. A. S. Eve found that a pressure of 20,000 atmospheres did not affect the radiation from radium *C*.

TABLE 1.—*Radium family.*

	Product.	Time required to be half transformed.	Radiations.	Range of α particle.	Velocity of α particle cm./sec. ÷ 10^9.	Physical and chemical properties.
	Uranium	(10)^9 years	α	*Cms.* 3.5	1.56	Soluble in excess of ammonium carbonate.
	Uranium *X*	22 days	β, γ			Insoluble in excess of ammonium carbonate.
	Ionium		α, β	3		This element resembles thorium in chemical properties and gives off no emanation.
	Radium	1300 yrs. (about).	α	3.5	1.56	Allied chemically to barium.
	Emanation	3.8 days	α	4.33	1.69	Inert gas of heavy molecular weight.
Active deposit of slow change.	Radium *A*	3 minutes	α	4.83	1.76	The active deposit is concentrated on the cathode in an electric field.
	Radium *B*	26 minutes	Weak β			
	Radium *C*	19 minutes	α, β, γ	7.06	2.06	
Active deposit of slow change.	Radium *D*	40 years	Rayless			Volatile below 1000° C.
	or Radiolead.					Stable at 1000° C.
	Radium *E*	4.8 days	β			
	Radium *E*	6 days	Rayless			Volatile at red heat and soluble in acetic acid.
	Radium *F*	140 days	α, δ	3.86	1.62	Deposited on bismuth in solution.
	or Palonium.					
	Lead		α(?)	12		Radium *D* and *F* are often found in commercial lead.

The effects of a very wide variation in temperature has also been studied. All experimenters find no variation until very high temperatures are reached and here different results are obtained. Doctor Bronson has recently found that a temperature of 1,600° C. did not change the activity of the emanation, radium *A*, radium *B*, or radium *C*. A few of the properties of the various radioactive products will be given in Table 1.

Quite recently the atomic weight of radium has been redetermined by Mme. Curie. She obtained .4 grams of radium chloride, which was as pure as she could make it. The purification consisted in fractional crystallization and precipitation, these being controlled by the spark spectra. When the purification was stopt the brightest barium lines were very faint. The mean of three determinations (letting the atomic weight of silver be 107.8 and chlorine 35.4) was 226.45. The value of the atomic weight of the emanation has been found by the diffusion method and comes out from 85 to 100. Ramsay believes that the emanation usually exists in the diatomic condition and that it belongs to the argon-helium group of elements. If this is true, he shows that its molecular weight should be about 216.5.

Soon after the discovery of radium the very remarkable discovery was made that it was continually emitting heat energy. J. Precht has recently determined the heat energy given off by radium bromide freed from water of crystallization. His results show that 1 gram of radium emits 122.2 calories of heat energy per hour. Surrounding the radium with a lead screen 1 millimeter thick, this becomes 126.9 calories per hour; and for a screen 3 millimeters thick, 134.4 calories. An increase of the screen beyond a thickness of 3 millimeters did not increase the amount of heat energy given off by more than .1 calory per hour. Taking the mean speed of the β particles to be 2.5×10^{10} centimeters per second, then the total mass of the β particles emitted in one hour is 1.6×10^{-12} grams. Lettting 4.5×10^{-24} be the mass of hydrogen molecule and knowing that a β particle possesses the mass of $\frac{1}{1000}$th that of the hydrogen atom, one finds that 1 gram of radium emits 2.2×10^{10} β particles per second.

Ramsey states that the emanation from 1 gram of radium evolves heat at the rate of 75 calories per hour. One cubic centimeter of the radium emanation would then give out a total heat energy of 7,000,000 gram calories. The chemical formation that produces the greatest amount of heat energy is the combination of hydrogen and oxygen in the proportion to make water. One cubic centimeter of this mixture will emit 3 gram calories in combining to form water.

THE α PARTICLES.

If e is the electric charge and m is the mass of the α particle, the value e/m has been determined to be 5.07×10^3 electromagnetic units. It thus follows that the radioactive elements and substances used in electric discharges have common particles whose value of e/m is the same as that of the α and β particles and which also possess the same properties. Whether all bodies emit these particles under ordinary conditions has not been fully settled, but the experimental evidences indicate that they do. From the above we found that the α particles cease to ionize the gas after traversing a distance which is equivalent to their range in air under normal conditions of pressure and temperature. Beyond this point the presence of the α particle can not be detected, so that if α particles were emitted by ordinary substances with a velocity less than the critical velocity their presence could not be detected by any known method.

The β particle is effective as an ionizing agent for about 100 centimeters producing about 130 ions per centimeter in air at standard conditions compared with 100,000 per centimeter produced by the α particles. For radium in equilibrium one β particle is emitted for every four α particles so that the β produce only about 1 per cent of the ionization.

The main source of the heat emission of radium is believed to be derived from the energy of the α particle. A great deal of work has recently been done upon the properties of these very interesting α particles. Not only are they emitted by radium, but by all the radio-elements and possibly by all metals. The α particles of all the radio-elements are found to differ only in the velocity of their projection, this velocity determining their range. Otherwise the α particles all appear alike.

For the α products from the various products of radium, Rutherford has found the empirical relation

$$V=0.348\,V_0\sqrt{r+1.25}$$

to hold between the range of the α particle and its velocity at any point in its path. Here V_0 is the initial velocity of the α particle emitted by radium C and is 2.06×10^9 centimeters per second, and r is the remaining part of the range which the α particle has to go from the point of its path which is being considered. From the above equation it follows that the initial velocity of expulsion of an α particle from a given product would then be a constant.

The γ and X-rays are very penetrating and produce very few ions per centimeter of path. They are usually believed to be pulses in the ether. W. H. Bragg has recently brought forth the theory that they consist of an α and β particle combined which have been shot off the radioactive atom. If this is true the electric field about this neutral particle would be very weak so that its penetrating power would be enormously increased. By means of this theory Bragg is enabled to explain many of the properties of the γ-rays.

Along an α particle's path the ionization is found to increase considerably near the end of the range. Plotting ionization as abscissas and distances from the radioactive surface as ordinates one gets an ionization curve. The area between the curve and axes gives the total ionization in the gas. By experimental means these curves come out the same in form no matter what the nature of the absorbing substance. The stopping power is a function of the atom and is unaffected by its association with other atoms in the molecular structure, and is independent of pressure and temperature. That is to say, the range of the α particle in a given gas can always be predicted from the composition of the gas molecule. Not only so, but stopping powers of various atoms are very nearly proportional to the square roots of atomic weights, both for gases and solids.

The α particles expend the same amount of energy no matter what the gas is, but in different gases a different number of ions will be formed as the table shows; but the stopping power is a function of the atomic weight which the total ionization is not. Plainly, then, the energy spent by the α particle and the resulting ionization are not directly connected. Bragg believes that there is a secondary ionization within the molecule. He shows that if δi is the ionization due to the expenditure of a small quantity of energy δz, then $\delta i=\kappa f(V)\,\delta z$ where $f(V)$ is a function of the velocity of the particle only and κ is a constant, being the specific ionization of a gas for the α radiation. Bragg shows that $f(V)$ is very probably $1/V$.

Considerable discussion has been held as to the nature of the α particles. If they are particles of matter belonging to the known list of elements, their value of e/m would indicate that they were either hydrogen or helium. If they consist of helium atoms they must carry two charges, however. These charges it may possess on ejection or acquire afterward. On the other hand, if they consisted of hydrogen, then hydrogen would accumulate in radioactive substances. This has not been found to be the case altho there is always helium present, and it is only in radioactive minerals that helium has been found. The presence of a light, inert gas-like helium was a sort of surprise to radioactivity students and lead Rutherford

to predict that helium was a disintegration product of radium. Ramsay and Soddy took up the work. They found the emanation to act like a very inert gas and to give a characteristic spectrum. After leaving the emanation to remain several days they found that helium lines began to appear. Thus it was shown that helium was a transformation product of radium. Whether the helium is one of the final products of the disintegration of the emanation or whether it consists of the expelled α particles has not been settled. Debierne has found that actinium also produces helium. Considerable helium has been found in thorium minerals indicating that helium is one of the products of the breaking down of thorium. But thorium and actinium have emanations like radium so that these facts do not aid in determining whether the α particles are the source of helium or not. Once the rate at which helium is liberated is known, it will be possible to say more. By this means it will also be possible to estimate the age of a radioactive mineral by the amount of helium occluded. Assuming the α particle to be helium, Rutherford has calculated the age of the minerals fergusonite and thorianite from their helium content and arrives at an age of about 400,000,000 years. In assuming radium and uranium to have attained radioactive equilibrium he finds that 1 gram of uranium will produce 6.3×10^{-8} cubic centimeters of helium per year.

DISTRIBUTION OF RADIUM.

Hitherto we have discust the very remarkable properties of radium. Now its wide distribution will be considered. Quite recently Strutt and Eve have determined the radium content of a considerable number of rocks. As this work has a very great geological significance a few of the results will be given. A solution of a definite amount of the rock was stored until the equilibrium amount of radium emanation had accumulated. The amount of emanation was then measured and the radium content determined.

TABLE 2.—*Distribution of radium.*

Name of rock.	Location.	Radium per gram.
		Grams.
Granite	Rhodesia	4.91×10^{-12}
Do	Cornwall	4.80×10^{-12}
Blue ground	Kimberley	1.73×10^{-12}
Leucite basanite	Vesuvius	1.71×10^{-12}
Hornblende diorite	Heidelberg	1.08×10^{-12}
Hornblende granite	Assouan, Egypt	1.26×10^{-12}
Angite syenite	Norway	$.95 \times 10^{-12}$
Granite	Isle of Rum	$.37 \times 10^{-12}$
Basalt	Greenland	$.31 \times 10^{-12}$
Native iron	do	$.22 \times 10^{-12}$
Meteoric iron	Thunda	*
Do	Virginia	*
Do	Santa Catarina	*
Essexite	Canada, Devonian period	2.6×10^{-12}
Tinguaite	do	4.3×10^{-12}
Do	do	3.0×10^{-12}
Nephelino syenite	do	1.1×10^{-12}
Oolite	Bath	3.00×10^{-12}
Marble	East Lothian	1.99×10^{-12}
Roofing slate	Wales	1.32×10^{-12}
Clay	Essex	$.89 \times 10^{-12}$
Red chalk	Hunstanton	$.55 \times 10^{-12}$
White marble	India	$.28 \times 10^{-12}$
Chalk (bottom of pit)	Cambridgeshire	$.40 \times 10^{-12}$
Chalk (top of pit)	do	$.12 \times 10^{-12}$
Deposit, hot springs	Bath	$.425 \times 10^{-12}$
Cambridge tap water		$.40 \times 10^{-12}$
Sea salt		$.077 \times 10^{-12}$
Boiler crust	Cambridge	$.04 \times 10^{-12}$
Sea salt	Omaha	$.020 \times 10^{-12}$
Sea water	Atlantic	$.003 \times 10^{-12}$
Trenton limestone, crystalline	Canada, Ordovician	$.92 \times 10^{-12}$
Trenton limestone, weathered	do	$.91 \times 10^{-12}$
Boulder clay	Canada, Quaternary	$.80 \times 10^{-12}$
Leda clay	do	$.78 \times 10^{-12}$
Saxicava sand	do	$.16 \times 10^{-12}$

* Indetectable.

These tables give typical examples of the rocks analyzed and show the wide distribution of radium in both igneous and sedimentary rocks. The average content of the rocks is high, whereas that of sea salt is quite small; the average for igneous is 1.7×10^{-12} grams of radium per gram and for sedimentary rocks 1.1×10^{-12}. The amount of radium content necessary to maintain the earth at a constant temperature is about 1.75×10^{-12} grams of radium per cubic centimeter of the earth. This is very much less than the radium content of any of the rocks. For this reason Strutt believes that radium is to be found only in the outer crust of the earth, at least if the earth is becoming cooler. In making his calculations Strutt does not consider the presence of radium and thorium and the possible radioactivity of ordinary materials. If the heating effect of ordinary substances is of the same order of magnitude as is to be expected from the ionization they produce, the earth's temperature gradient would be many times larger than that observed. Strutt believes this to be an argument against the view that ordinary matter possesses a natural radioactivity of its own.

C. B. Thwing claims, however, that he has been able to find a temperature gradient in small cylinders of the various metals and rocks. At present then the exact heating effect of the radioactive substances in the rocks is not known. J. Joly believes that the radium content of sedimentary rocks is greater than for igneous ones. Thick strata of sedimentary rocks might then be a very important element of mountain building by raising the temperature of the base of the mass. Joly finds that a specimen of red clay (2700 fathoms in North Atlantic) contained sixteen times as much radium as the average igneous rocks, and globigerina ooze (1990 fathoms, South Atlantic), six times as much.

Some very interesting work has recently been done by Strutt upon the content of helium and argon in the rocks, with results as shown in the following table:

TABLE 3.—*Strutt's results.*

Mineral.	Amount analyzed.	Nitrogen.	Argon.	Neon.	Helium.
	Grams.	*cc.*	*cc.*		*cc.*
Commercial pumice stone, Lipari Island	480	3.5	.049	Argon and neon	None
Beryl	250				4.2
Matopo granite	850	11	.14	Traces	.04
Syenite rock, Leicestershire	900	9	.026	Traces	.010
Bath		100	1.5	Traces	.12
Forty springs in France		Present	Present		Present
Syenite, greenstone and red sandstone		Present	Present		Present

RADIOACTIVITY OF THE ATMOSPHERE.

After considerable work had been done upon ionization it was found that ordinary free air was ionized. Now in the table of transformation products of the radio-elements, it will be noticed that several of the products have the property of condensing upon a highly negatively-charged wire. Elster and Geitel tried exposing charged wires in the open air and found that an active deposit of radium and thorium formed on the wire. The amount of active deposit was found to depend upon the locality and the weather conditions. If the air had been undisturbed for some time, as the air in caves and cellars, it was found that the active deposit formed was much greater. Air sucked thru the pores of the ground was found to be very active. Elster and Geitel concluded from these results that the radium and thorium emanations (which behave like gases) ooze thru the ground and percolating waters and have their origin in the radium and thorium of the soil. The emanation then breaks up into various products as given in Table 1. During this time the emanation gives rise to positively charged carriers, which are driven to a negatively charged wire by the electric field. It is to the emanation and its products that the ionization of the air is attributed.

Thorium *C* and radium *C* give off γ rays and as these are very penetrating, they would be the source of a very penetrating radiation, and this latter was discovered several years ago. The ionization in a closed vessel is measured, and thick lead screens are then placed around the electroscope, and the ionization again measured. The ionization in the latter case is found to be very considerably decreased, the penetrating radiation having been largely cut off. Whether all the pene-

trating radiation can be explained as due to radium *C* and thorium *C* will be taken up later.

As the potential of the earth is negative compared with that of the air, the active deposit is dragged down to the surface of the ground and upon the leaves and branches of plants and trees. A hill or mountain top concentrates the earth's field and so receives a greater amount of the active deposit.

In this way Elster and Geitel explain the greater ionization on hills and mountains. Experiments show that the active deposit tends to collect upon dust particles and these serve as nuclei for the condensation of raindrops and snowflakes. The deposit resulting from evaporating rain and snow should be very radioactive. This was found to be true by Wilson and Allen. Again a big rain or snow should carry down most of the active deposit, and as the emanation does not emit γ rays, the amount of γ radiation from the radioactive matter in the air should be very much decreased. The penetrating radiation, if it consists mainly of γ rays, should then become very small. This has been borne out by experiments made by the writer. As the emanation does not seem to be carried down by the snow and rain, the products, radium *C* and thorium *C*, would soon be in equilibrium again after a rain or snow. The experimental evidence indicates that the radiation comes mainly from products in the air and not from those in the ground. The amount of this penetrating radiation varies enormously.

The effect of the presence of radioactive matter in the atmosphere upon ordinary phenomena is perhaps very great, tho at present little is known. It has been found that deep wells and hot springs contain considerable radium. From this Elster and Geitel suggest that the curative effect of thermal springs and the physiological action of the air at high levels may be related to the large amount of radioactive matter present. The presence of radioactive matter, and therefore of ionization, in the air probably plays a very important rôle in the growth of plants. It has been found that vegetables grown in an atmosphere electrified positively are much above those grown in normal fields both in quantity and quality. The ionization and nucleation produced by radioactive matter in the air may be very essential for the condensation of rain and hail, and serve to explain the enormous accumulation of static electricity during thunderstorms.

Simpson and others have measured the activity of the air which has blown over the sea and have found it small. Now if most of the radium and thorium emanations come from the pores of the soil and underground cavities, the results obtained by the above investigators would be expected, for, as will be seen from Table 2, the radium content of ocean water is very small. Eve has recently measured the ionization over the ocean and has found it to be the same as the ionization over the land; a rather unexpected result. In this state the matter rests at present. A crucial test would be to expose negatively charged wires far out in the ocean and study the active deposit, or to test for the presence of a penetrating radiation. According to J. Joly, the distinguished geologist, Eve's results can easily be explained. Geologists have for some time made an approximate estimate of the age of the oceans by making determinations of the amount of salt which they contain. By analyzing the waters of rivers flowing into the ocean for the salt which they contain and determining the total annual outflow of all the rivers into the ocean, and supposing these constants to have been practically constant during the past, it is easy to make an estimate of the approximate age of the oceans. Now if radium and uranium always exist in a constant proportion, the present radium content of the ocean would have been supplied by the rivers in a comparatively short length of time. For this and other reasons Joly believes that uranium and radium are not always to be found associated together. Now we know that radium has a short period of decay so that it must be constantly supplied from somewhere. Joly believes that the source is at least partly outside the earth. This radium is gradually being brought down to the surface. This would account for the ionization over the ocean and the wide distribution of radium over the earth. Elster and Geitel's theory of the escape of the emanation from the upper layers of the soil would still hold true. If radium exists outside the earth, it would be expected that the upper layers of the earth's atmosphere would be highly ionized by the γ rays. This highly ionizing radiation would serve to explain some of the phenomena of atmospheric electricity. According to C. T. R. Wilson, the positive potential of the atmosphere is largely to be attributed to the carrying down of negative charges by raindrops and snowflakes. The upper layers of the atmosphere, being highly ionized and quite good conductors, would conduct the remaining positive charge to places of lower potential, and would thus always aid in equalizing the potential of wet and dry regions.

FAMILY HISTORY OF RADIUM.

In unaltered minerals which have been formed during the same geological period and which contain radioactive elements, one would expect to find all the products of disintegration in radioactive equilibrium if the minerals were of sufficient age. If the minerals are not old enough for this radioactive equilibrium to have been established, then the proportion of each disintegration product with respect to the parent substance must be greater in those minerals which are the older and should correspond with the order of the respective geological ages of the localities in which the minerals have been formed. In secondary minerals, which have been formed by the subsequent alteration of the original primary minerals, the relative amounts of the disintegration products would be less than in the primary minerals from the same locality. For instance, if radium was a disintegration product of uranium, since radium has a comparatively short period of decay, we would expect to find a constant ratio between the amount of radium and the amount of uranium in a mineral. This has been found to be true. A large number of uranium minerals have been investigated, and it has been found that for every gram of uranium there are 3.8×10^{-7} grams of radium accompanying it.

Doctor Boltwood has investigated the ratio of the amounts of lead and uranium and of helium and uranium. He finds that the ratio of lead to uranium is constant for uranium minerals of the same locality. The ratio of helium to uranium has also been found to be fairly constant under the same conditions, altho on account of the ease of escape of helium one would not expect the figures to agree as closely. Following is a table containing some of Boltwood's results.

TABLE 4.—*Boltwood's results.*

Name of mineral.	Number of analyses.	Average per cent of uranium.	Average per cent of lead.	Average ratio of lead to uranium.	Locality.	Age of mineral in millions of years.
Uraninite	5	70.8	2.92	.041	Glastonbury, Conn	410
Uraninite	4	72.25	3.875	.0535	Branchville, Conn	535
Uraninite	3	73.66	3.8	.052	Spruce Pine, N. C	510
Uraninite	1	71.0	3.3	.046	Marietta, S. C	460
Uraninite and mackintoshite.	3	43.3	7.43	.18	Llano County, Texas	1,800
Samarksite	3	4.10	.80	.20	Douglas County, Colo	1,900
Uraninite	3	49.7	6.13	.13	Annerod, Norway	1,700
Thorianite	4	11.25	2.50	.22	Sabaragamuva Prov., Ceylon	2,200
Thorianite	1	25.0	2.1	.086	Calle District, Ceylon	860

McCoy and Ross have made very careful estimates between the activity of a pure uranium compound and a uranium mineral, and have found the mineral to be 4.58 times as active as the corresponding pure uranium compound. The activity

of a quantity of uranium is 1.87 times as active as that of the radium in equilibrium with it. Now radium in equilibrium with the emanation and radium *A* and *C* is 5.64 times as active as radium alone. Now assuming radium *F* to have an activity in proportion to the range of its α particles, it would be 1.10 times as active as radium. So radium and its products are 6.74 times as active as radium. A uranium mineral should be 6.74+1.87 or 8.61 times as active as the equilibrium amount of radium or 4.60 times as active as the uranium it contains.

These results show very conclusively that radium is a disintegration product of uranium.

If radium is considered a transformation product of uranium, as these and other experiments indicate, and further since the range of the α particles of uranium and radium is the same, and if the activity is assumed proportional to the range, then for equilibrium amounts of uranium and radium there will be twice as many α particles emitted by uranium as radium. But only one product of the uranium group emits α particles, so that it seems very probable that there is a product between uranium and radium that emits α particles.

Radium has been found to increase in amount in uranium and actinium solutions by Boltwood and Rutherford. Boltwood has succeeded in separating the radium parent from an actinium solution by precipitation with sodium thiosulphate. This radium parent he calls ionium and finds its activity about equal to that of radium in equilibrium with it. No emanation has been found as yet to issue from ionium. It emits very slow α particles and resembles thorium in its chemical properties.

Soddy has recently dissolved uranium minerals in ether several times and has tried various methods of purifying his radioactive substances. Using 250 grams of uranium which has been dissolved in ether for several days, he finds no radium at the end of six hundred days. Neither could he detect any growth of actinium in a uranium solution or any radium in an actinium solution which he had purified. It thus seems quite probable that uranium breaks down into ionium, ionium into radium, and radium later on breaks down into lead. Whether actinium is related in any way to the radium family of elements is at present unknown.

THE RADIUM EMANATION.

The radium emanation is probably the most unique substance known. It was discovered in 1900 by Dorn. It was found to comport itself as an intensely radioactive gas. It was early found that the various compounds of radium differed very much as to the amount of emanation which they emitted under ordinary conditions. This emanating power is greatly increased by the presence of moisture. Radium chloride emits but little emanation in a dry gas, but when the surrounding gas becomes moist the emanating power is much greater. By solution or by the heating of a radium compound the amount of emanation set free is greatly increased. A solution of radium chloride has been found to have 200 times the emanating power of dry salt. Heating radium compounds to a red heat increases the emission of emanation 10,000 times. Cooling decreases the emission. The emanating power depends upon the physical and chemical conditions under which the radium exists. But the amount of emanation formed is entirely independent of these conditions.

The radium emanation possesses the greatest content of potential energy of any substance known. One cubic centimeter liberates 3,000,000 times as much heat energy as a cubic centimeter of hydrogen and oxygen mixt in the proportion to make water. A 1-pound weight of the emanation would at its maximum activity radiate energy at the rate of 10,000 horse power. Ramsay has found that the emanation is produced from 1 gram of radium at the rate of 3×10^{-6} cubic millimeters per second. A very considerable amount of work has been done upon the radium emanation by Ramsay and other men working with him. They have investigated many of its properties and have discovered some very remarkable facts.

When the emanation acts on water it is found that oxygen and hydrogen are formed, the hydrogen being always in excess. The following table will give some of the results:

Weight of $RaBr_2H_2O$ in solution.	Time of collection of gases.	Volume of gas.	Volume/gram/100 hours.	Excess of hydrogen.
Grams.	*Hours.*	*Cu. cm.*	*Cu. cm.*	*Per cent.*
.0600	168	2.88	28.6	4.44
.1090	240	8.91	34.0	3.65
.1000	336	16.43	44.9	6.13
.1000	158	5.09	30.3	3.76
.1000	168	4.93	29.3	7.23
.1620	48	3.18	41.8	7.83
			Mean..32.0	5.51

The action of the emanation was exactly analogous to that of the radium salt itself. If the emanation is past into a mixture of oxygen and hydrogen, it will cause these two gases to combine to form water.

Ramsay and Collie have found that the emanation obeys Boyle's law quite closely. The following are a few of their results. Immediately after admitting the emanation the following readings were taken:

Temperature.	Pressure.	Volume.	V×P
°C.	mm.†	cu. mm.	
17.9	28.0	10.08	282
	53.5	5.04	269.5
	235.1	1.11	260.0
16.9*	195.7	.70	137.5
	70.7	2.03	143.1
	42.2	3.54	149.3
	18.2	8.39	152.7

*1½ hours later. †In millimeters of frequency.

The following figures show the sudden change in the volume of the emanation. On account of this sudden change of volume Ramsay and Collie believe that the emanation exists in two forms which they call emanation 1 and emanation 2. The results of their experiments indicate that the law of Charles is not obeyed.

Time, in minutes.	Volume in cubic millimeters.
0	.397
15	.351
22	.291
30	.247
45	.205
61	.199
95	.194

The experiments on the action of the radium emanation on water showed that the water was decomposed into oxygen and hydrogen, with always an excess of hydrogen. With the view that this might be pseudo-electrolysis, Cameron and Ramsay thought they would see what would happen when a copper solution was treated with the radium emanation. No copper was deposited; but on investigating the products it was found that a trace of lithium was present in the copper solution along with a considerable amount of sodium. This experiment was carried out during the summer of 1906, and the result was so unexpected and so important that the experiment has since been twice repeated, always with the same results.

In general, Cameron and Ramsay find that the dry emanation, decomposing spontaneously, produced an inactive gas which shows a briliant spectrum of helium, with possibly a trace of neon. When the emanation is dissolved in water, neon and a trace of helium are produced, and when in a saturated copper sulphate solution, argon. a trace of neon, and lithium result.

TABLE 5.—*Cameron and Ramsay's experiments.*

Solution.	Nature of bulb.	Amount of emanation.	Time.	Removal of Cu.	Residues.	Results.
		Cu. mm.	*Days.*			
Experiment I. Saturated solution of copper sulphate recrystalized four times.	Soda-lime glass bulb.	3	30	H_2S	Sodium and calcium.	Red line of lithium appeared.
Experiment II. Saturated solution of copper sulphate prepared by electrolysis.	Glass vessel.	3	30	H_2S	1.1 mgs	Sodium spectrum and red lithium line.
Experiment III. Saturated solution of copper nitrate prepared chemically.	Platinum vessel.	1.5	41	H_2S	2.48 mgs	Sodium and lithium spectra.
Experiment IV. Saturated solution of copper nitrate. (*a*) Extreme care was used in preparation of chemicals.	Vessels mostly of platinum and silica.	1.6	42	H_2S	1.67 mgs	Residual gases. NO 1.12 cc. N_2 .34 cc. CO_2 .27 H_2 .44 cc. O_2 1.12 cc. Argon, sodium, and lithium spectra.
(*b*) Control ex. Saturated solution of copper nitrate.	Vessels of platinum and silica.	.....	42	.....	.79 mgs	Sodium strong, no lithium present.
(*c*) Distilled water..	Glass bulb.	1.44	38	.....	.71 mgs	N_2 .307 cc. CO_2 .065 cc. CO .030 H_2 3.74 O_2 1.56 cc. Brilliant neon spectrum. Sodium and potassium but no lithium.

Cameron and Ramsay have also tried passing the emanation into a lead nitrate solution, but were unable to get any spectrum of lithium. Experiment IV, which they made, was performed with all the care possible. During the first day the copper nitrate treated with the emanation became slightly cloudy, on the second day slightly green, after which the green did not become any more distinct. From this solution there was a greenish white deposit. The color of the untreated copper nitrate remained a clear blue thruout the experiment and gave no residual gas. The bulbs used were made from the same piece of glass tubing.

Cameron and Ramsay suggest that helium may result from the degradation of the large molecule of the emanation from its bombardment by the α particles; that this degradation, when alone or with oxygen, results in the lowest member of the inactive series of elements, helium. If particles of greater mass are associated with the emanation as liquid water, then the degradation is less complete and neon is produced; when the associated molecules are still more complex, as copper sulphate, then the product is argon. These writers also believe that copper is also involved in this process of degradation and is reduced to the lowest member of its group of elements, namely, lithium. Whether sodium is also produced is difficult to say on account of its presence in the glass bulb used.

The above experiments, if verified, are fundamentally of the greatest importance, and the theory of radioactivity will now take on an entirely new phase. Previously all experimental data indicated that the process of disintegration of the elements was unaffected by any known physical or chemical methods. But here we have a process of controlling this transformation. Strutt's work on the occurrence of argon, neon, and helium in the rocks goes to partly confirm the work of Cameron and Ramsay.

SUMMARY.

1. We have found that radium is a very remarkable element on account of its spontaneous emission of α, β, γ, and δ radiations.

2. It is an element that is rapidly disintegrating into products which have entirely different physical and chemical properties.

3. Radium is very widely distributed thruout the rocks of the earth, and exists in but small amounts in sea water.

4. It is quite possible that a part of the radium of the earth is of extra terrestrial origin.

5. The atmosphere contains several of the radium products.

6. Radium is a member of a family of elements which are disintegrating into a final product, lead.

7. The radium emanation evolves helium constantly.

8. Recent work indicates that under different conditions different elements are produced in the breaking down of the radium emanation. If this is true, it is quite possible that the argon, helium, and neon in the air may be due to the presence of radium.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Assistant Librarian.

THE INTERNATIONAL METEOROLOGICAL COMMITTEE.

The reports of the meetings of the International Meteorological Committee—in English, French, and German—are published from six months to two years after the meetings; the English versions by the British Meteorological Office, the French usually by the Bureau Central Météorologique de France, and the German by either the Prussian Meteorological Institute, or the Zentralanstalt für Meteorologie at Vienna. We have recently received the German report of the meeting held in Paris last September.[1]

The sessions began Tuesday morning, September 10, the following members of the Committee being present: Hellmann, Lancaster, Mohn, Nakamura, Palazzo, Pernter, Rykachev, Shaw, and Hildebrandsson (secretary). Messrs. Angot and Hergesell were present as guests. In the absence of Professor Mascart, Doctor Shaw, director of the British Meteorological Office, acted as presiding officer. Prof. Mascart, President of the Committee, being detained at his home in Poissy by ill-health, invited the Committee to hold one of its sessions there, and the invitation was accepted.

A letter was read from Doctor Hann, presenting to the Committee his three memoirs on the daily march of temperature in the Tropic Zone, recently published by the Vienna Academy of Sciences. General Rykachev presented the report of the committee on terrestrial magnetism and atmospheric electricity, and also announced the appointment by the International Association of Academies of a committee charged with the execution of magnetic measurements along a parallel of latitude. Doctor Hergesell presented the report of the aeronautical committee. This report included a detailed account of the upper air observations made during the "international week" of July, 1907. Reference was also made to the inauguration of several new institutions for upper-air research; e. g., the Prussian observatory at Lindenberg, the observatory of the U. S. Weather Bureau at Mount Weather, and the private observatory of M. Riabouchinsky at Koutchino, Russia. Doctor Shaw reported that the observations with pilot balloons made at Cairo, Egypt, showed the occurrence of a steady west wind above the 1,200-meter level in that locality. A special committee was appointed to investigate the system of communicating weather information to vessels in use at the Zikawei Observatory, China, with a view to its universal adoption. A recommendation that the maximum and minimum temperatures in the past twenty-four hours be included in morning weather telegrams was adopted. A proposal by Doctor Shaw, looking to the adoption of a uniform scale and projection for daily weather maps and marine meteorological charts, to correspond with the requirements of dynamic meteorology, was approved in principle, but it was not deemed feasible to secure such uniformity at present.

The afternoon session was occupied with the important question of the publication of mean or normal values from the

[1] Bericht über die Versammlung des Internationalen meteorologischen Komitees, Paris, 1907. Berlin, 1908. (Veröffentlichungen des K. Preuss. Meteorologisches Instituts, Nr. 191).

long records that now exist for a great many stations thruout the world. Such means have heretofore been published in an irregular and desultory manner, and with little regard to uniformity of epoch. The Committee voted to encourage the publication of means for each lustrum ending in '5 and '0; and a compilation of climatological data for Japan on this basis was submitted by Doctor Nakamura[1]. The Committee decided to call upon the directors of meteorological services for lists of the publications in which means from many-year records have appeared. Such lists were subsequently furnished and are published as an appendix to the report (Anhang XIII). They fill a long-felt want in climatological literature—notwithstanding the regrettable omission of some important countries; notably, India, the Australasian states, and the Argentine Republic!

In this connection may be mentioned a long report of the solar committee, published as an appendix to the publication under review, but not referred to in the procès-verbaux. The solar committee has called upon the meteorological services of the world for compilations of mean values of the meteorological elements from a certain number of representative stations, based on the uniform period 1881–1905; also a statement of regional rainfall for each country.

At the morning meeting of September 11 special committees were appointed to prepare new isothermal charts of the world, and to consider an interesting project of Teisserenc de Bort for promptly centralizing the reports of daily observations made at some thirty selected stations scattered over the world. The Committee decided to request the Deutsche Seewarte to enlarge the scope of its "Dekadenberichte" so as to include the intertropical regions of the Atlantic Ocean.

At the afternoon meeting wireless telegraphy was discust and a new committee on weather telegraphy, with especial reference to wireless telegraphy, was appointed. Doctor Shaw presented a statement showing that at a maximum cost of £1,000 a year the effective range of the European daily weather maps could be extended by means of wireless messages to the meridian of 15° or 20° W. of Greenwich. At the instance of Doctor Hildebrandsson it was decided to urge the meteorological services to establish stations in the neighborhood of the "action centers" of the atmosphere.

On the morning of the 12th a special session was held at Professor Mascart's home in Poissy, some twelve miles from Paris, and on this occasion Professor Mascart took leave of his colleagues, having resigned from the Committee in consequence of his retirement from the directorship of the meteorological service of France. Doctor Shaw exprest the profound regret of the Committee at the loss of its president, who had conducted its affairs with distinguished success for fourteen years.

The final session was held the same afternoon in Paris. A code of rules governing the international organization of meteorology was adopted provisionally, pending ratification by the next International Meteorological Conference. Doctor Shaw was unanimously elected president of the Committee in succession to Professor Mascart, and the following were elected members of the Committee, to fill vacancies: Angot, Hamberg, Maurer, Stupart. Doctor Hildebrandsson resigned from the Committee, and Doctor Hellmann, director of the Prussian Meteorological Institute, was elected to succeed him as secretary. A report of the committee on solar radiation was received from Professor Ångström, stating that some thirty observatories in different parts of the world were now using his electric compensation pyrheliometer; also outlining a project for the comparison of instruments. At the same time Professor Ångström tendered his resignation from the committee on radiation on account of ill health, and Doctor Pernter was chosen to succeed him, temporarily, as chairman. The last act of the meeting was the adoption of a suggestion of General Rykachev that portraits of all the members of the Committee be collected in an album and presented to the retiring president, Professor Mascart.

Taking account of the deaths that have occurred since the Paris meeting the membership of the International Meteorological Committee now stands as follows:

Prof. Dr. Alfred Angot, Directeur du Bureau Central Météorologique de France, Paris; Commandante Francisco S. Chaves, Director do Serviço Meteorologico dos Açores, Ponta Delgada, Azores; Gualterio G. Davis, Director de la Oficina Meteorológica Argentina, Buenos Aires; Dr. H. E. Hamberg, Direktor der Meteorologischen Centralanstalt, Stockholm, Sweden; Geh. Regierungsrat Prof. Dr. G. Hellmann, Direktor des Preussischen Meteorologischen Instituts, Berlin; St. C. Hepites, Directeur supérieur honoraire de l'Institut Météorologique de Roumanie, Bucharest, Roumania; Dr. J. Maurer, Direktor der Schweizerischen Meteorologischen Centralanstalt, Zürich, Switzerland; Prof. Dr. H. Mohn, Direktor des Meteorologischen Instituts, Christiania, Norway; Prof. Willis L. Moore, Chief of the United States Weather Bureau, Washington; K. Nakamura, Director of the Central Meteorological Observatory, Tokyo, Japan; Prof. Dr. Luigi Palazzo, Direttore dell'Ufficio, Centrale di Meteorologia e di Geodinamica, Rome; Hofrat Prof. Dr. J. M. Pernter, Direktor der Zentralanstalt für Meteorologie und Geodynamik, Vienna; Maj.-Gen. M. Rykachev, Director of the Central Physical Observatory, St. Petersburg; Dr. W. N. Shaw, Director of the Meteorological Office, London; R. F. Stupart, Director of the Meteorological Service of Canada, Toronto.

CHANGES IN "DAS WETTER."

The monthly meteorological journal, Das Wetter, has enlarged its scope by inaugurating a department devoted to the new Public Weather Service of Germany, in which the observers of that service will be at liberty to express their views, offer suggestions, and report experiences of meteorological interest, much as the "British Rainfall" observers do in the columns of Symons's Meteorological Magazine. The new department will be under the editorship of Prof. R. Börnstein.

Das Wetter has for a number of years been, in a sense, subsidized by the Prussian Meteorological Institute, i. e., the Institute subscribes for a large number of copies for presentation to its voluntary observers. Now an arrangement has been made whereby the meteorologists of the Institute are to collaborate more generally than heretofore in the production of the journal, which thus assumes a quasi-official character, denoted by the addition of "Mit Unterstützung des Königlich Preussischen Meteorologischen Instituts" to its title.

A NEW WEATHER MAP FROM AUSTRALIA.

Commonwealth meteorology having become *fait accompli* in Australia, Australasia once more boasts a daily weather map, which dates from January 1, 1908. The area embraced is nearly the same as that of the large maps formerly published at Sydney and Brisbane, with the addition, however, of some noteworthy stations in outlying islands. A small inset is provided for the report from Cocos Island (latitude 12° 5′ S., longitude 96° 54′ E.), which lies beyond the limits of the general map. The size of the map is somewhat less than twice that of a page of the MONTHLY WEATHER REVIEW.

The data charted are barometric pressure, state of the sky, direction of the wind, state of the sea, occurrence of thunderstorms, and occurrence, but not amount, of rainfall. Temperature statistics are not included.

SIR JOHN ELIOT.

Several meteorologists of the first rank have past away within the last twelvemonth, but none whose loss will be more

[1] Results of the meteorological observations made in Japan for each period of five years since 1876, and for the 10, 15, 20, 25, 30 years ending in 1905; published by the Central Meteorological Observatory, Tokio, in 1906.

keenly felt than that of Sir John Eliot, K. C. I. E., F. R. S., the great authority on the meteorology of India, who died suddenly at his home, Bon Porto, Cavalaire, in the south of France, March 18, 1908.

He was born at Lamesley, Durham, in 1839, and took a degree at Cambridge in 1869, winning special honors in mathematics. On leaving the university he proceeded at once to India, where he taught mathematics successively at Rurki and Allahabad. In 1874 he was appointed professor of physical science at the Presidency College, Calcutta, and also meteorological reporter to the government of Bengal. In 1886 he became meteorological reporter to the government of India, on the retirement of Mr. Blanford, and held this post until his own retirement in 1903.

During his régime the number of meteorological observatories in India was nearly doubled, a uniform system of marine storm warnings was adopted, flood warnings were inaugurated, the work of collecting meteorological information relating to the Indian seas was largely extended, a solar physics observatory was established at Kodaikánal for the systematic study of solar changes and their correlation with the larger features of Indian meteorology, and seasonal forecasts of rainfall were undertaken, in an experimental way, in response to the immense need felt for such information by the Indian agriculturists; these being the first long-range forecasts issued by an official weather service and based upon generally admitted scientific principles.

Sir John Eliot's contributions to Indian meteorology by no means ceased with his retirement from official life. The most recent numbers of the Indian Meteorological Memoirs, published only last year, were from his pen; and in 1906 appeared the great work which may be regarded as the roof and crown of his scientific career—the "Climatological Atlas of India." A companion volume, "Handbook of the Meteorology of India," was to have been ready for publication shortly, and he was engaged upon this only two days before his death. He was an active member of the International Meteorological Committee, retaining his membership after his retirement from the Indian service in 1903, at the urgent request of the committee, in exception to the rule that the personnel of the committee shall be limited to the directors of meteorological services. He was also secretary of the International Solar Commission.

Of all Eliot's scientific achievements perhaps that which most interested meteorologists in America was the great impulse that he gave to correlative meteorology on a world-wide scale—"world meteorology"—whether viewed as a subject complete in itself, or as a chapter in cosmical physics. His address as chairman of the subsection of cosmical physics at the Cambridge meeting of the British Association, in 1904, may be said to mark an epoch in meteorological opinion; and his suggestive papers on the meteorology of large areas of the earth's surface during the period 1892–1902[1] are the expression of similar views in a more concrete form. It is said that he was looking forward to attending the meeting of British meteorologists to be held in Ottawa next summer—an enterprise for which he himself was probably in a large measure responsible.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

H. H. KIMBALL, Librarian.

The following titles have been selected from among the books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be loaned for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

[1] Broad Views, Vol. I, March, 1904, and Indian Meteorological Memoirs, Vol. XVI, pt. 2.

American climatological association.
Transactions. v. 23. Philadelphia. 1907. xxxii, 330 p. 8°.

Austria. K. k. hydrographisches Zentralbureau.
Der Gewitterregen des 17. Juli 1907 im Nordwesten von Wien. Wien. 1908. 8 p. 8°. (Sonderabdruck aus der "Oesterr. Wochenschrift für den öffentl. Baudienst," Heft 41, 1907.)

Bach, Hugo.
Das Klima von Davos nach dem Beobachtungsmaterial der eidgenössischen meteorologischen Station in Davos. Zürich. 1907. 105 p. f°. (Nouveaux mémoires de la Société Helvétique des sciences naturelles. Bd. 42, Abh. 1.)

Bemporad, A.
... L'assorbimento selettivo dell'atmosfera terrestre sulla luce degli astri. Roma. 1905. 109 p. 4°. (Reale accademia dei Lincei. Anno 301, 1904.)

Blanco Juste, Rafael.
Elementos de fisica y nociones de meteorologia ... Parte primera. Madrid. 1906. 280 p. 8°.

Canada. Meteorological service.
Report of the Meteorological service of Canada ... 1905. Ottawa. 1907. xix, 418 p. 4°.

Carnegie institution of Washington.
Year book. No. 6, 1907. Washington. 1908. vii, 242 p. 4°.

Colorado. Agricultural experiment station.
Climate of Colorado; temperature, 21 years' record at Fort Collins. 1908.

Costa, B. C. Cincinnato da, and Castro, D. Luiz.
Le Portugal au point de vue agricole. Lisbonne. 1900. xxxviii, 965 p. f°.

Eredia, Filippo.
I venti in Italia. Roma. 1907. f°. (Estratti dal Bollettino della Società aeronautica Italiana.)

Everdingen, E. van.
... Relations between mortality of infants and high temperatures. (Koninklijke akademie van wetenschappen te Amsterdam.) Repr. from Proc. of the meeting of Saturday Oct. 26, 1907. 13 p. 4°.

Félice, Raoul de.
La Basse-Normandie. Paris. 1907. 590 p. 8°.

Geneva. Observatoire.
Observations météorologiques faites aux fortifications de Saint-Maurice. 1906. Genève. 1907. 56 p. 8°.
Résumé météorologique de l'année 1906 pour Genève et le Grand Saint-Bernard. Genève. 1907. 109 p. 8°.

Geographisches Jahrbuch.
Gotha. 1907. xiv, 397 p. 8°.

Germany. Deutsche Seewarte.
Deutsches meteorologisches Jahrbuch für 1906. Hamburg. 1907. vi, 200 p. f°.
29ᵉʳ Jahresbericht ... 1906. Hamburg. 1907. iv, 49 p. 4°.

Great Britain. Meteorological office.
Meteorological observations at stations of the second order for the year 1903. Edinburgh. 1908. xiv, 169 p. f°.

Hongkong observatory.
China coast meteorological register. 1907. n. p. f°.

Houston, Edwin J.
The wonder book of the atmosphere. New York. 1907. x, 326 p. 12°.

Huntington, Ellsworth.
The pulse of Asia; a journey in central Asia illustrating the geographic basis of history. Boston. 1907. xxi, 415 p. 8°.

Johnson, Kenneth S.
Mean monthly and annual relative humidity charts of the United States. Cape Town. 1907. p. 161–168. 8°. (From the report of the South African association for the advancement of science, 1906.)

Kassner, —.
Die Witterung im Sommer 1907 und ihr Einfluss auf den landwirtschaftlichen Betrieb. (Sonderabdruck aus dem Jahrbuch der Deutschen Landwirtschafts-Gesellschaft. Band 22. p. 765–776. 8°.)

Kayser, E.
Wolkenhöhenmessungen. (Sonderabdruck aus dem Schriften der Naturforschenden Gesellschaft in Danzig. N. F. Band 9. Heft 1. 1895.)

Keeling, B. F. E.
The climate of Abbassia near Cairo. Cairo. 1907. 61 p. 4°.

Krümmel, Otto.
... Handbuch der Ozeanographie. Bd. 1. Stuttgart. 1907. xv, 525 p. 8°.

Lehmann, Alfr. and Pedersen, R. H.
Das Wetter und unsere Arbeit; experimentelle Untersuchungen über den Einfluss der meteorologischen Faktoren auf die körperliche und seelische Arbeitsfähigkeit. Leipzig. 1907. p. 99–202. 8°. (Sammlung von Abhandlungen zur psychologischen Pädogogik aus dem Archiv für die Gesamte Psychologie. 2. Bd. 2 Heft.)

Lisbon. Observatorio do Infante D. Luiz.
Annaes. v. 40–43, 1902–1905. Lisboa. 1904–1907. f°.
Annaes. Observaçoes dos postos meteorologicos. 1902–1905. Lisboa. 1906–7. 4°.

Lodge, Oliver.
Electrons; or the nature and properties of negative electricity. London. 1907. xv, 230 p. 8°.

Magelssen, A.
...Wetter und Krankheit. Hefte 1–5. Christiania. 1894–1906. 97 p. 8°.

Mysore. Meteorological department.
Mysore meteorological memoirs. No. 2. Containing for the period of the twelve years 1895 to 1906 the means of the hourly records of the weather elements obtained with the self-recording instruments at the Bangalore observatory ... Bangalore. 1908. 32 p. f°.

Netherlands. Koninklijk nederlandsch meteorologisch instituut.
Jaarboek. 1906. A. Meteorologie. B Aard-magnetisme. Utrecht. 1907. f°.

Polis, P[eter].
Der Wetterdienst und die Meteorologie in den Vereinigten Staaten von Amerika und in Canada. Berlin. 1908. 43 p. 4°.

Ruppel, Sigwart.
Vereinfachte Blitzableiter. Berlin. 1907. 106 p. 16°.

South Kensington. Solar physics observatory.
Report ... 1907. [London.] 1908. 18 p. 8°.

Southern Rhodesia. Statist.
Report on meteorology for the year ended 31st March, 1907. 23 p. f°.

Steffens, Otto.
Die Methoden und Instrumente der Feuchtigkeitsbestimmung. Separatabdruck aus der Fachzeitschrift "Der Mechaniker." Berlin. 57 p. 4°.

Stonyhurst college observatory.
Results of meteorological and magnetical observations, 1907. Liverpool. 1908. xiii, 65 p. 12°.

Thompson, Jean M.
Water wonders every child should know. New York. 1907. xvii, 233 p. 12°.

Zagreb. Meteorologisches Observatorium.
Jahrbuch ... 1903–1906, 3. Theil. Zagreb. 1906–1907. f°.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

H. H. KIMBALL, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

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Bell, Louis. Note on some meteorological uses of the polariscope. p. 407–412.

American climatological association. Transactions. Philadelphia. v. 23. 1907.

Hart, James A., and F[isk], S[amuel] A. In memoriam. Samuel Edwin Solly. p. XXV–XXVIII.

Wellman, F. Creighton. Report on the climate, natural history, and disease incidence of the Angola highlands. p. 21–39. [Includes one year's observations at Bailundu.]

Carrington, Paul M. The climate of New Mexico—nature's sanatorium for consumptives. p. 71–100.

Fremont-Smith, F. The effect of Florida climate upon acute and chronic disease. p. 117–125. [Includes data for Palm Beach.]

Anders, Howard S. Influenza and weather instability. p. 229–235.

American geographical society. Bulletin. New York. v. 40. March, 1908.

Ward, R. DeC. Kassner's meteorological globes. p. 148–150.

American journal of science. New Haven. 4th ser. v. 25. Apr., 1908.

Dadourian, H. M. On the constituents of atmospheric radioactivity. p. 335–342.

Engineering news. New York. v. 59. Apr. 16, 1908.

—— Air-resistance experiments by a novel method. p. 413. [Abstract of paper by Eiffel.]

Geographical journal. London. v. 31. Mch., 1908.

Cornish, Vaughn. The Jamaica earthquake (1907). p. 246–276.

Holdich, T. H. General Sir Richard Strachey. p. 342–344.

Nature. London. v. 77. March 12, 1908.

MacDowell, Alex. B. Rothesay summers and Greenwich winters. p. 438–439.

Physical review. Lancaster. v. 143. Feb., 1908.

Allen, S. J. Radioactivity of a smoke-laden atmosphere. p. 206–208.

Scientific American. New York. v. 98. Apr. 11, 1908.

—— The use of balloons for the prevention of hail. p. 262.

Symons's meteorological magazine. London. v. 43. March, 1908.

Russell, Spencer C. Some observations on mist, fog, and cloud. p. 37–38. [Notes the different effects of chalk and clay soils on overlying mist and fog.]

—— Hygrometers without calculation. p. 28–29. [Description of the "hygrodeik" and of a horticultural hygrometer for predicting frost.]

Aérophile. Paris. 16 année. 15 mars 1908.

Macaluso, Eugenio. Les oiseaux, les aéroplanes et le coefficient de la résistance de l'air. p. 102–104.

Tatin, Victor. Le coefficient de la résistance de l'air. p. 104–106.

Almanach de la conquête de l'air. 1908. [Mons.]

[**Bracke, A.**] Comment on mesure la température de l'air. p. 129–148. [Includes numerous illustrations of thermometers and screens.]

[**Bracke, A.**] Croyances de Noël. Folklore météorologique. p. 162–163.

[**Bracke, A.**] L'Observatoire Flammarion à Juvisy. p. 165–168.

Ciel et terre. Bruxelles. 29 année. 16 mars 1908.

Vincent, J. L'étude des nuages. p. 25–29.

Lagrange, E. Quelques données sismologiques. p. 42–45.

Société belge d'astronomie. Bulletin. Bruxelles. 13 année. Fév., 1908.

Arctowski, H. Recherches sur la périodicité des phénomènes météorologiques a Bruxelles. p. 54–68.

—— La théorie de M. Oddone et les observations de Cartuja en 1907. p. 84–85.

Société météorologique de France. Annuaire. Paris. 56 année. Jan., 1908.

Maillet, Edmond. Les prodromes des crues dans le bassin de la Seine. p. 10–13.

Lemoine, G. La vie et l'oeuvre scientifique de M. Antoine d'Abbadie (1810–1897). p. 14–18.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 36 Jahrgang. 1908.

—— Die Witterung und phänologischen Erscheinungen zu Tsingtau in dem Jahre vom Dezember 1906 bis zum November 1907. p. 97–109.

Schott, Gerhard. Die Wärmeverhältnisse auf dem Dampferwege zwischen der Deutschen Bucht und New York, dargestellt in Isoplethen-Diagrammen. p. 110–116.

Gaea. Leipzig. 44. Jahrgang. April, 1908.

—— Die Drachenstation am Bodensee. p. 226–227.

Meteorologische Zeitschrift. Braunschweig. Band 25. März, 1908.

Nippoldt, A. Bemerkungen zu neuen Karten des Feldes der täglichen Variation des Erdmagnetismus. p. 97–103.

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TORNADO OF JANUARY 31, 1908.

By W. S. BELDEN, Section Director. Dated Vicksburg, Miss., February 17, 1908.

A tornado of remarkable energy and duration formed in the eastern portion of Jefferson County, Mississippi, at about 1:45 p. m., January 31, 1908, and moved in an easterly and east-northeasterly direction across Copiah County and to central Simpson County, covering a total distance of about 60 miles in approximately one hour and forty-five minutes.

So far as could be learned the tornado was destructive thruout its entire course, and its path varied from 100 yards to one-half mile in width. Seven people were reported killed by the storm, and thirty injured, and the value of property destroyed was conservatively estimated at $100,000. Fortunately the country thru which it past is sparsely settled, otherwise the loss of life would have been much greater.

During the forenoon of January 31, fresh to brisk southerly winds and cloudy weather, with occasional light showers, prevailed over Mississippi in connection with a large barometric depression central over Oklahoma at 7 a. m. Toward noon the temperature rose rapidly over southern Mississippi, reaching a maximum near or above 70°. At Vicksburg the barometer fell steadily until 1:30 p. m., when the reading was 29.64 inches, and a few minutes after 2 p. m. the wind veered to west and attained a maximum velocity of 41 miles per hour at 2:13 p. m.

The tornado cloud was first seen passing over Delmar shortly before 2 p. m., moving in an easterly direction. It appeared black and was attended by a high wind, heavy rainfall and considerable hail.

Observers who saw the destructive cloud generally described it as being black and funnel-shaped, and the noise emanating from it was referred to as resembling the sound made by a heavily loaded freight train running at a high rate of speed. At some places near the path of the storm the thunder and lightning were severe, while at other places they were only moderate, The rainfall was generally heavy, especially just after the passage of the tornado; and many places reported a light fall of hail.

At 2 p. m. the tornado past close to Union Church in southeastern Jefferson County, and was described as follows by Prof. A. C. Wharton at that village:

> During the morning and forenoon of the 31st the sky was overcast and the temperature rose, reaching 71°. Toward noon the clouds thickened and grew darker, especially along the northern and western horizon. Just before 2 p. m. they became very threatening and soon attention was attracted by the roar of distant winds. The clouds were in tumultuous agitation in the west and were rapidly driven in our direction. Then the funnel-shaped cloud became visible, and this, together with the hoarse bellowing of the now nearby wind, apprised us that we were witnessing a tornado. It passed within about 200 yards of us, apparently from a due westerly direction, and it was accompanied and followed by torrents of rain. We saw trees uprooted, or snapped off midway of the trunk, and noticed much small débris flying thru the air, torn from trees and house tops. From our first observation until it had swept by us was, I think, not over one and one-half or two minutes. Altho its path was nearly one-half mile wide, its most destructive energy was confined to a track about 300 or 400 yards wide. Observers who were watching the storm from points just outside its path, reported that buildings were hidden from view by a momentary darkness, when enveloped by the whirl. On the almost instantaneous disappearance of the smoke-like veil, such buildings were seen to be totally destroyed. The darkness, according to them, was apparently caused by clouds being drawn down in the vortex until they came into literal contact with the ground. The number of buildings destroyed within a mile of here was large; most of them were of small value, being negro cabins, barns, etc. Nobody was fatally hurt.

After passing Union Church the tornado moved east-northeast, plowing its way across fields and thru woodlands, demolishing fences, trees, cotton houses, negro cabins, plantation homes, cotton gins, saw mills, etc. It reached Homochitto at 2:20 p. m. and ten minutes later it was mowing a path thru the Bowerton neighborhood. Mr. A. M. Millsaps, postmaster at Bowerton, stated that it was the most destructive storm that ever visited this community and that all stock in the path of the tornado were killed. He reported that a tenant house on his farm was entirely blown away and no part of it had been found; there were five grown negroes in this house at the time of this occurrence and not one of them received a scratch.

The heaviest losses occurred at Martinsville which was struck at 2:45 p. m., the path of the tornado crossing the railroad one-half mile north of the depot. Twelve families were left homeless, and it was in this place that six of the seven persons killed met death.

Continuing its course in a nearly straight line the funnel-shaped cloud continued its work of devastation, passing north of Ashley and crossing the Pearl River at Georgetown, where it was reported as being low on the ground. Sixteen people were injured at Georgetown.

In the vicinity of Bowers at about 3:30 p. m., the tornado lost its destructive violence, but the rainfall was very heavy in that section causing small streams to overflow their banks. Many places in central and western Simpson County, some as far as twelve miles from the storm track, reported the atmosphere to be filled with leaves, twigs, and small branches of trees.

It was the most destructive atmospheric disturbance that has visited Copiah County since the Beauregard tornado of 1883, in which nearly 100 people were reported to have been killed.

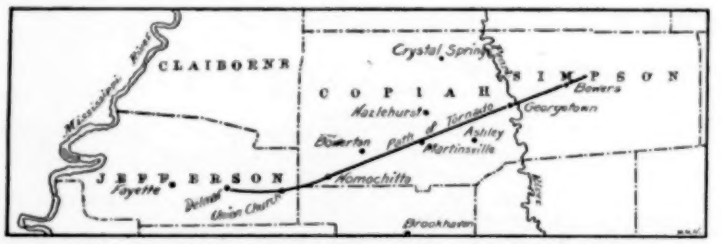


FIG. 1.—Path of tornado in southeastern Mississippi.

THE WEATHER OF THE MONTH.

By Mr. P. C. DAY, Assistant Chief, Division of Meteorological Records.

PRESSURE.

The distribution of mean atmospheric pressure for March, 1908, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

Mean pressure above the normal for March prevailed over nearly all portions of the United States and apparently over the greater part of Canada, the only exception being a small area including the upper Mississippi Valley and the western and northern portions of the Lake Superior district, where average pressure slightly below the normal was maintained.

The mean pressure ranged from .10 to .15 inch above the normal over the Atlantic and middle and north Pacific coast districts, maintaining average values above 30.20 inches over northern California and western Oregon.

There was a general increase in pressure from that of the preceding month on both the Atlantic and Pacific coasts, the increase along the Pacific coast amounting to more than .10 inch. Over all interior districts of the United States and Canada the average pressure was less than that for February, 1908.

The general distribution of the more or less permanent areas of high and low pressure was such as to give prevailing southerly winds over Texas, the middle and lower Mississippi

Valley, and thence eastward to the Atlantic coast, including the Ohio Valley and lower Lake region. Over New England and from the upper Lake region westward to the Rocky Mountains the winds were mainly from the northwest, while westerly winds prevailed over the Plateau and Pacific coast districts.

Over nearly all interior districts there was less storm activity than usually prevails in March, and this condition was general also over the central and south Pacific coast districts. Over the southern portion of the Great Plains the decrease in wind movement ranged from 15 to 35 per cent.

Along the Gulf and Atlantic coasts and from Lake Superior westward along the northern boundary to the Pacific there was a general excess of storm activity and a consequent increase in the average wind velocity over those districts.

TEMPERATURE.

March, 1908, like the same month of 1907, was an unusually warm month over nearly all portions of the United States. No periods of widespread or intense heat occurred, but the weather was uniformly mild thruout the month.

From the south Atlantic coast westward to the Rocky Mountains the average temperature ranged from 6° to more than 8° above the normal, and over most of the Gulf States there were but few days during the month when the temperature was not above the seasonal average.

A slight deficiency prevailed along the north Pacific coast, also over the northern Rocky Mountain districts and thence eastward along the extreme northern border to the Lake Superior district, extending across the border into the Northwest Provinces of Canada, where the temperature ranged from 4° to 6° below the normal.

High maximum temperatures prevailed over the Gulf and South Atlantic States from the 17th to 19th and at scattered points on other dates, but aside from the above the extremes of temperature were not abnormal.

Temperatures as low as 32° were recorded in the northern portions of the cotton-growing States, over central and western Texas, and over the whole of New Mexico, Arizona, and California, except at the lower elevations and along the coast. Frosts were frequent over Arizona and the greater part of California, but no severe cold weather for the season occurred. Minimum temperatures from 10° to slightly more than 20° below zero were recorded in northern New England, and from the Upper Michigan Peninsula westward to the Rocky Mountains. The remaining portions of the United States were remarkably free from low temperatures.

PRECIPITATION.

Over the greater portion of the United States the month was one of deficient precipitation. In the Ohio Valley there were several periods of heavy precipitation, causing high waters in the tributaries of that river, and there were local heavy rains in portions of the Middle Atlantic and east Gulf States, and snowfall was heavy from the upper Lakes westward to the Rocky Mountains; elsewhere the precipitation was generally light.

Marked deficiencies occurred over New England, the Florida Peninsula, most of the Gulf States, and California. Over the Florida Peninsula the total fall was but little more than 10 per cent of the average, and over most of California it was scarcely one-third the usual fall, practically no rain occurring after the 5th of the month.

Over nearly all portions of the Great Plains, Mountain, and Plateau districts the precipitation was less than 1 inch, and in large sections of the southern Rocky Mountain slope barely more than traces of rain occurred.

Over the coast districts of Washington and in the mountains of that State and Oregon there were heavy local falls, ranging from 10 to as much as 25 inches, depending upon the exposure, the heaviest precipitation occurring on the western slopes of the Coast and Cascade ranges of mountains. The distribution of precipitation for the month is graphically presented on Chart IV by appropriate shading or by figures representing the actual fall.

SNOWFALL.

The distribution of the total snowfall for the month is graphically shown on Chart VII.

In general it was light over nearly all eastern and southern districts and to a great extent over the mountain and Plateau districts of the West.

From the upper Lakes westward along the northern tier of States to the Rocky Mountains, the monthly snowfall was rather heavy, ranging from 10 to 20 inches, and in portions of northern Michigan from 20 to more than 35 inches.

At the end of the month the ground was bare of snow, except over northern New England, the northern portions of Michigan, Wisconsin, and Minnesota, in portions of North Dakota and Montana, where snow was falling at the end of the month, and in the high levels of the mountain and Plateau districts.

In general there was less snow in the mountains than usual at the season of the year, but the prospects were good for an average flow of water over most districts, due to the hardened condition of the snow, much of which, having fallen early in the season, has become hardened by alternate thawing and freezing and is therefore in the best condition to furnish water late in the season.

HUMIDITY AND SUNSHINE.

Despite the general lack of precipitation over the South Atlantic and Gulf States and the southern portions of the slope and mountain regions, the relative humidity over those districts ranged from 5 to 10 per cent above the average. It was also above the average over the Middle Atlantic States, Kentucky, and Tennessee, and over the northern portions of the States from Lake Superior to the Rocky Mountains. Over northern New England and the interior districts from the lower Lakes westward to the Pacific coast and over southern California, there was a general deficiency in the average relative humidity.

Over the south Atlantic and east Gulf States and the Florida Peninsula the amounts of sunshine ranged from 60 to 80 per cent of the possible. Over most of California and southwestern Arizona it ranged from 70 to 80 per cent, and there was generally an abundance of sunshine over the districts west of the Mississippi River, except along the northern border from the Great Lakes westward to the Pacific.

In general the month was unusually favorable for all outdoor occupations from the Atlantic to the Pacific, except over portions of the Ohio Valley and along the northern border west of the Great Lakes, where, on account of the frequent occurrence of snow or rain and the absence of sunshine, outdoor occupations were largely at a standstill.

WEATHER IN ALASKA.

Reports covering the coast districts from the southern extremity to the Alaska Peninsula show the prevalence of moderate temperatures during the month, with an apparent excess of clear, pleasant weather. Precipitation was comparatively light, except over the districts around the mouth of the Copper River and about Cook Inlet, where considerable snow occurred. A heavy snowstorm prevailed over those districts from about the 18th to 22d, the fall at Fort Liscum during that period aggregating nearly 4 feet. At the end of the month heavy snow still remained on the ground in the districts near the coast from Mount St. Elias westward to Cook Inlet, the depths ranging from 3 to nearly 6 feet. There was apparently no great amount of snowfall in the interior districts.

Severe cold prevailed over the eastern interior districts during the middle portion of the month, temperatures slightly more than 50° below zero being recorded in the vicinity of the Arctic Circle, and more than 40° below in the Klondike districts.

An unusually extensive aurora was observed at numerous points in the Territory during the nights of the 26th and 27th, some of the observers stating it was the most brilliant and extensive display ever witnessed in the Territory. Reports from Canada indicate that it was observed over nearly all portions of that country, and in the United States it was observed over the entire northern portion from the Atlantic to the Pacific, extending as far south as Virginia and North Carolina and the lower Missouri Valley.

In Canada.—Director R. F. Stupart says:

The mean temperature for March exceeded the average over the lower mainland of British Columbia, southern Alberta, and a large portion of Ontario; elsewhere in Canada the temperature was subnormal.

The precipitation, which in all the provinces was part rain and part snow, was below the average over the larger portion of the Dominion. The amount recorded near the coast of British Columbia, however, was nearly double the normal, and over northern Alberta, part of Saskatchewan, northwestern Quebec, Prince Edward Island, and in Cape Breton the average was exceeded.

At the close of the month the ground was bare of snow in southern Alberta, the Peninsula of Ontario, southern New Brunswick, and Nova Scotia; elsewhere in Canada the covering was light, except in the northern portions of Saskatchewan and Ontario, where the depth of snow on the ground exceeded 20 inches. In Quebec the amount on the ground ranged from 10 inches at Montreal to 42 inches at Quebec.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	34.6	+ 1.6	+ 0.8	+ 0.3
Middle Atlantic	16	44.8	+ 4.6	+ 2.2	+ 0.7
South Atlantic	10	60.2	+ 6.4	+ 2.5	+ 0.8
Florida Peninsula*	8	70.2	+ 3.5	+ 1.5	+ 0.5
East Gulf	11	64.4	+ 7.1	+ 3.7	+ 1.2
West Gulf	10	63.8	+ 6.5	+11.1	+ 3.7
Ohio Valley and Tennessee	13	50.7	+ 6.4	+ 5.6	+ 1.9
Lower Lake	10	35.4	+ 3.1	+ 1.2	+ 0.4
Upper Lake	12	29.8	+ 2.6	+ 7.0	+ 2.3
North Dakota*	9	21.7	+ 0.3	+20.1	+ 6.7
Upper Mississippi Valley	15	41.1	+ 5.0	+12.7	+ 4.2
Missouri Valley	12	41.8	+ 5.7	+19.5	+ 6.5
Northern Slope	9	32.0	+ 1.2	+11.7	+ 3.9
Middle Slope	6	48.3	+ 5.8	+18.1	+ 6.0
Southern Slope*	7	58.0	+ 6.0	+13.2	+ 4.4
Southern Plateau*	12	51.0	+ 2.1	+ 5.1	+ 1.7
Middle Plateau*	10	39.7	+ 1.7	+ 5.3	+ 1.8
Northern Plateau*	12	38.5	+ 1.3	+ 7.3	+ 2.4
North Pacific	7	44.0	— 0.2	+ 3.1	+ 1.0
Middle Pacific	8	52.9	+ 0.5	+ 1.3	+ 0.4
South Pacific	4	56.9	+ 1.8	+ 3.7	+ 1.2

* Regular Weather Bureau and selected cooperative stations.

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
	%			%	
New England	75	0	Missouri Valley	68	— 4
Middle Atlantic	74	+ 6	Northern Slope	67	0
South Atlantic	79	+ 4	Middle Slope	55	— 5
Florida Peninsula	81	+ 4	Southern Slope	52	— 3
East Gulf	80	+ 7	Southern Plateau	41	+ 3
West Gulf	77	+ 5	Middle Plateau	52	— 4
Ohio Valley and Tennessee	72	+ 1	Northern Plateau	61	— 5
Lower Lake	76	0	North Pacific	80	+ 2
Upper Lake	77	— 2	Middle Pacific	67	— 6
North Dakota	80	+ 2	South Pacific	64	— 7
Upper Mississippi Valley	72	— 3			

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		Inches.	Inches.
New England	12	2.82	76	—0.9	—1.0
Middle Atlantic	16	2.75	75	—0.9	—0.6
South Atlantic	10	3.70	86	—0.6	—0.9
Florida Peninsula*	8	0.40	12	—2.8	—4.1
East Gulf	11	4.62	79	—1.2	—0.8
West Gulf	10	2.19	71	—0.9	—1.5
Ohio Valley and Tennessee	13	5.08	113	+0.6	—0.1
Lower Lake	10	2.92	111	+0.3	+1.0
Upper Lake	12	2.24	100	0.0	+0.3
North Dakota*	9	1.33	143	+0.4	+0.7
Upper Mississippi Valley	15	1.93	79	—0.5	—0.4
Missouri Valley	12	1.36	69	—0.6	—0.1
Northern Slope	9	1.17	109	+0.1	—0.3
Middle Slope	6	0.36	25	—1.1	—0.8
Southern Slope*	7	0.43	38	—0.7	—1.0
Southern Plateau*	12	0.55	58	—0.4	—0.1
Middle Plateau*	10	0.77	56	—0.6	—0.9
Northern Plateau*	12	0.84	63	—0.5	—1.8
North Pacific	7	5.08	104	+0.2	—1.4
Middle Pacific	8	1.11	29	—2.7	—1.6
South Pacific	4	0.57	22	—2.0	—0.3

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	6.3	+ 0.7	Missouri Valley	5.7	+ 0.1
Middle Atlantic	6.1	+ 0.6	Northern Slope	5.9	+ 0.6
South Atlantic	4.6	— 0.1	Middle Slope	4.8	+ 0.4
Florida Peninsula	2.6	— 1.4	Southern Slope	4.9	+ 0.7
East Gulf	5.0	+ 0.3	Southern Plateau	3.5	+ 0.5
West Gulf	5.3	+ 0.1	Middle Plateau	4.0	— 0.9
Ohio Valley and Tennessee	6.7	+ 0.8	Northern Plateau	6.2	— 0.3
Lower Lake	7.2	+ 0.8	North Pacific	6.7	+ 0.1
Upper Lake	6.7	+ 0.8	Middle Pacific	3.3	— 1.7
North Dakota	6.6	+ 1.1	South Pacific	2.9	— 1.6
Upper Mississippi Valley	6.0	+ 0.5			

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Amarillo, Tex	5	53	sw.	North Head, Wash	10	56	se.
Buffalo, N. Y	7	50	sw.	Do	12	62	s.
Do	11	51	sw.	Do	13	66	s.
Burlington, Vt	6	50	s.	Do	15	60	se.
Do	26	70	s.	Do	24	74	se.
Do	28	51	s.	Oklahoma, Okla	5	58	s.
Canton, N. Y	26	50	sw.	Pittsburg, Pa	15	67	w.
Chicago, Ill	6	54	w.	Point Reyes Light, Cal.	16	60	nw.
Cleveland, Ohio	6	52	sw.	Do	17	60	nw.
Do	26	56	s.	Do	18	52	nw.
Columbus, Ohio	15	70	w.	Do	24	50	nw.
Detroit, Mich	6	54	sw.	Do	26	56	nw.
El Paso, Tex	5	56	w.	Do	27	56	nw.
Jacksonville, Fla	24	68	s.	Do	28	52	nw.
Kansas City, Mo	5	56	s.	Do	29	52	nw.
Do	6	54	s.	Do	30	65	nw.
Do	26	54	s.	Do	31	61	nw.
Modena, Utah	25	50	sw.	Pueblo, Colo	5	55	w.
Mount Tamalpais, Cal	16	56	nw.	Do	6	50	w.
Do	17	58	nw.	Richmond, Va	15	52	nw.
Do	21	52	ne.	Southeast Farallon, Cal.	17	50	nw.
Do	24	60	nw.	Syracuse, N. Y	6	50	s.
Do	25	58	nw.	Do	15	52	w.
Do	26	72	nw.	Do	26	52	s.
Do	27	62	nw.	Tatoosh Island, Wash	12	54	s.
Do	30	64	nw.	Do	13	50	s.
Do	31	64	nw.	Do	15	52	s.
Mount Weather, Va	19	61	nw.	Do	17	50	w.
Nantucket, Mass	15	56	sw.	Do	24	52	s.
New York, N. Y	15	51	w.	Toledo, Ohio	6	57	sw.
Do	16	57	nw.	Do	26	54	sw.
North Head, Wash	1	50	s.	Do	28	55	w.

CLIMATOLOGICAL SUMMARY.

By Mr. JAMES BERRY, Chief of the Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, MARCH, 1908.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	62.4	+ 6.2	Decatur	92	18	Riverton	25	21	4.77	— 1.04	Spring Hill	7.43	Goodwater	2.24
Arizona	55.8	+ 1.4	3 stations	98	3 d't's	Chlarsons Mill	2	6	0.84	— 0.28	Chlarsons Mill	4.00	3 stations	T.
Arkansas	59.5	+ 7.1	Jonesboro	93	16	Pond	21	10	3.79	— 1.43	Mena	7.67	Rogers	1.82
California	51.8	+ 0.7	Mammoth Tank	100	15	Fordyce Dam	—10	6	1.49	— 2.03	Cisco	11.30	11 stations	0.00
Colorado	37.5	+ 3.9	Rocky Ford	86	17	Wagon Wheel Gap	—26	9	0.52	— 0.69	Silverton	3.91	2 stations	0.00
Florida	69.3	+ 3.8	Brooksville	95	30	Johnstown	35	1	0.78	— 2.66	Molino	5.01	2 stations	0.00
Georgia	62.7	+ 6.1	Louisville	94	16	Clayton	27	21	4.65	+ 0.15	Morgan	8.42	Valdosta	0.06
Hawaii	69.6†		Kihei, Maui	88	31	Humuula, Hawaii	30	3 d't's	8.81‡		Olokele Ditch, Kauai	22.74	Waimea, Hawaii	1.03
Idaho	36.2	+ 1.2	Hotspring	78	14	Paris	—12	9	1.55	— 0.51	Burke	7.18	Lost River	0.13
Illinois	44.7	+ 5.2	3 stations	83	18, 27	Zion	13	9	3.09	— 0.09	Chester	5.57	2 stations	0.73
Indiana	45.2	+ 5.7	3 stations	80	18, 27	Plymouth	12	3	4.42	+ 0.83	Marengo	7.80	Kokomo	2.57
Iowa	37.9	+ 3.9	Woodburn	85	25	Inwood	— 8	8	1.58	— 0.34	LeClaire	3.74	Ames	0.45
Kansas	48.3	+ 5.7	Ashland	94	4	Norton	8	9	0.81	— 0.64	Independence	4.18	Coolidge	0.00
Kentucky	51.8	+ 5.5	Catlettsburg	88	18	Farmers	19	21	5.42	+ 0.18	Catlettsburg	8.56	Blandville	2.89
Louisiana	66.8	+ 6.0	Opelousas	93	18, 19	Minden	32	12	3.17	— 1.82	Robeline	7.44	New Iberia	0.70
Maryland and Delaware	45.9	+ 3.7	Keedysville, Md.	85	27	Deer Park, Md.	11	21	3.00	— 0.79	Deer Park, Md.	7.34	Jewell, Md.	1.36
Michigan	30.9	+ 1.9	Charlotte	79	26	Humboldt	—28	9	2.63	+ 0.30	Cassopolis	5.70	Sault Sainte Marie	0.95
Minnesota	26.4	+ 1.3	St. Peter	74	26	McIntosh	—38	8	1.47	+ 0.07	Stillwater	3.25	Angus	0.66
Mississippi	63.3	+ 5.7	4 stations	91	18	Ripley	26	21	4.67	— 1.04	Canton	7.04	Columbia	0.90
Missouri	50.1	+ 6.1	Olden	89	18	§Sublett	14	9§	2.58	— 0.99	Greenville	6.65	Oregon	0.34
						§Unionville	14	9§						
Montana	30.1	+ 1.1	Toston	68	15	Lubec	—20	5	1.58	+ 0.37	Snowshoe	11.93	Decker	0.20
Nebraska	40.0	+ 4.5	§Hebron	90	25§	Hay Springs	— 4	7	0.46	— 0.65	Santee	2.14	3 stations	0.00
			§Lynch	90	25§									
Nevada	40.7	+ 2.0	Las Vegas	91	17	Palmetto	— 6	7	0.30	— 1.05	Eureka	1.95	4 stations	0.00
New England*	33.1	+ 2.1	Waterbury, Conn	77	27	Van Buren, Me	—22	11	2.77	— 1.17	Provincetown, Mass.	4.53	Jacksonville, Vt.	1.20
New Jersey	41.8	+ 2.9	Browns Mills	89	27	Layton	7	1	2.80	— 1.26	Trenton	4.92	Pleasantville	1.06
New Mexico	47.8	+ 3.6	Carlsbad	92	16, 17	Rociada	— 3	9	0.34	— 0.32	Elizabethtown	1.60	15 stations	0.00
New York	32.7	+ 1.5	Port Jervis	81	27	Indian Lake	—22	1	2.69	— 0.59	Wappinger Falls	4.66	Romulus	0.65
North Carolina	55.9	+ 5.6	Kinston	91	18	Banners Elk	14	21	4.95	+ 0.21	Snow Hill	7.19	Lenoir	2.58
North Dakota	21.1	— 0.3	Haley	68	8	Mayville	—31	30	1.16	+ 0.13	Haley	2.90	Walhalla	0.08
Ohio	43.4	+ 4.7	New Alexandria	85	28	Bladensburg	12	10	5.43	+ 1.93	Philo (2)	8.41	Willoughby	2.25
Oklahoma	56.2	+ 5.6	3 stations	98	17, 18	Gage	11	11	1.68	— 0.52	Durant	5.36	2 stations	0.00
Oregon	43.0	+ 0.8	Vale	77	24	Christmas Lake	— 3	4	3.77	— 0.47	Glenora	19.80	Prineville	T.
Pennsylvania	40.7	+ 3.8	§Bellefonte	83	28§	Pocono Lake	— 4	25	4.76	+ 1.01	Johnstown	10.00	Dushore	1.58
			§Hyndman	83	26, 27§									
Porto Rico	73.3		§Dorado	92	2§	§Aibonito	52	4§	5.60		Comerio Falls	11.49	Vieques	2.56
			§Vieques	92	23§	§Juana Diaz	52	30§						
South Carolina	61.4	+ 6.3	4 stations	90	3 d't's	§Dillon	29	21§	4.56	+ 0.43	Effingham	7.00	Georgetown	1.75
						§Santuc	29	22§						
South Dakota	32.3	+ 3.1	§Alexandria	86	25§	Cherry Creek	—21	8	1.17	— 0.08	Milbank	2.53	Oelrichs	0.40
			§Forestburg	86	25§									
Tennessee	56.4	+ 7.0	Dover	90	18	Rugby	15	21	4.37	— 1.31	Pope	7.10	Springdale	2.84
Texas	64.3	+ 6.4	Graham	103	18	Plemons	13	11	1.65	— 0.33	Denison	5.80	5 stations	0.00
Utah	39.8	+ 1.1	Milford	90	12	Woodruff	—20	7	1.10	— 0.40	Ranch	2.88	3 stations	T.
Virginia	50.2	+ 5.0	Arvonia	86	27	Burkes Garden	8	21	3.53	— 0.45	Speers Ferry	6.73	Riverton	1.52
Washington	42.5	+ 0.8	Mottingers Ranch	76	24	Twisp	0	6	5.03	+ 1.01	Clearwater	25.09	Trinidad	0.00
West Virginia	47.8	+ 4.7	Logan	89	18	4 stations	15	21	6.04	+ 1.75	Rowlesburg	8.60	Harpers Ferry	1.23
Wisconsin	31.3	+ 2.4	Waukesha	72	26	Long Lake	—18	9	2.14	+ 0.16	Beloit	3.58	2 stations	0.94
Wyoming	30.4	+ 2.2	Fort Laramie	78	25	Fayette	—24	8	0.95	— 0.54	Snake River, Y. N. P.	4.84	Phillips	T.

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. †51 stations, with an average elevation of 737 feet. ‡143 stations.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Assistant Chief, Division of Meteorological Records.

For description of tables and charts see page 8 of REVIEW for January, 1908.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, March, 1908.*

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
New England.							34.6	+ 1.6								25	23	75	2.82	— 0.9									6.3	
Eastport	76	69	85	29.94	30.03	+ .10	28.7	— 0.2	50	24	36	— 1	10	22	31	27	23	78	3.96	— 0.3	14	9,621	nw.	48	s.	26	5	14	12	6.4	25.2
Greenville				28.83	30.05		22.6		48	23	34	—18	21	12					2.95		10		se.							
Portland, Me.	108	81	117	29.94	30.07	+ .11	32.3	+ 0.3	56	24	40	6	10	24	35	29	23	70	2.26	— 1.5	12	7,012	nw.	38	s.	15	5	14	12	6.4	9.7
Concord	288	70	79	29.76	30.08	+ .08	33.4	+ 1.9	60	26	23	4	11	24	46				1.68	— 1.7	14	4,764	nw.	29	sw.	15	11	9	11	5.5	7.6
Burlington	404	12	47	29.60	30.07	+ .07	28.4	— 1.3	56	26	38	1	10	19	35				1.74	— 0.1	15	10,188	s.	70	s.	26	5	11	15	6.7	9.7
Northfield	876	16	70	29.08	30.06	+ .06	27.3	+ 1.1	62	27	38	— 8	10	16	49	26	21	76	2.17	— 0.6	18	7,442	s.	42	se.	13	4	12	15	7.1	11.5
Boston	125	115	188	29.94	30.08	+ .11	38.6	+ 3.6	70	27	47	15	10	31	32	35	30	73	2.97	— 1.1	15	8,570	sw.	39	sw.	26	6	8	17	6.6	4.8
Nantucket	12	14	90	30.07	30.08	+ .10	37.3	+ 0.5	56	12	43	18	10	31	25	36	33	87	2.74	— 1.2	16	12,514	sw.	56	sw.	15	9	13	9	5.9	0.4
Block Island	26	11	46	30.06	30.09	+ .11	37.3	+ 2.4	55	14	43	18	10	31	18	35	31	80	3.28	— 1.1	18	12,748	sw.	48	nw.	16	7	16	8	5.5	0.9
Narragansett		9					37.4	+ 2.4	60	12	45	12	1	30	26				3.85		16		w.				16	7	8		3.5
Providence	160	57	67	29.92	30.10	+ .12	37.8	+ 2.1	64	28	46	14	10	29	30	33	28	71	3.42	— 0.7	18	5,728	w.	29	sw.	26	7	13	11	6.0	6.0
Hartford	159	122	132	29.92	30.10	+ .11	37.4	+ 2.4	75	27	46	13	1	29	31	33	27	70	3.06	— 1.3	13	5,360	nw.	36	sw.	26	7	9	15	6.9	2.6
New Haven	106	116	155	29.98	30.10	+ .11	38.8	+ 3.4	66	27	47	15	1	31	28	34	29	71	3.78	— 0.7	14	6,831	n.	38	nw.	16	8	11	12	6.1	7.8
Mid. Atlantic States.							44.8	+ 4.6										74	2.75	— 0.9									6.1	
Albany	97	102	115	29.98	30.10	+ .09	35.4	+ 3.3	65	28	44	9	1	27	33	32	27	73	1.43	— 1.3	14	6,394	s.	37	s.	26	8	14	9	6.0	5.6
Binghamton	871	78	90	29.12	30.08	+ .06	34.8	+ 2.8	72	28	43	2	1	26	30				3.12	+ 0.5	13	5,289	nw.	39	w.	16	3	6	22	8.1	9.3
New York	374	108	350	29.75	30.10	+ .10	41.4	+ 3.9	75	27	48	23	10	34	27	37	31	70	2.15	— 2.0	13	8,900	nw.	57	nw.	16	10	8	13	5.9	3.5
Harrisburg	374	94	104	29.70	30.11	+ .08	42.7	+ 4.9	77	27	50	22	1	35	34	37	31	67	3.72	+ 0.2	12	5,826	nw.	43	nw.	15	8	10	13	5.9	3.3
Philadelphia	117	116	184	30.00	30.13	+ .11	45.0	+ 5.0	78	27	53	24	1	37	34	40	35	73	2.83	— 0.6	11	7,847	s.	36	sw.	15	9	10	12	5.8	2.1
Scranton	805	111	119	29.21	30.09	+ .07	38.4	+ 3.5	77	27	47	13	1	30	34	34	29	70	3.62	+ 0.5	12	5,593	sw.	34	w.	16	4	9	18	7.3	7.7
Atlantic City	82	37	48	30.07	30.13	+ .11	41.8	+ 5.0	64	12	48	24	21	36	26	38	34	78	1.77	— 2.0	11	6,355	sw.	26	s.	15	8	8	15	6.4	2.0
Cape May	17	48	52	30.12	30.14	+ .13	42.8	+ 2.0	62	28	49	24	21	37	23	39			1.87	— 1.9	13	6,350	s.	30	nw.	30	10	9	12	5.6	2.5
Baltimore	123	100	113	29.97	30.11	+ .08	47.1	+ 5.2	80	27	55	27	21	39	35	41	37	73	2.50	— 1.4	12	5,634	nw.	30	s.	15	5	11	15	6.8	0.5
Washington	112	59	76	29.99	30.12	+ .08	47.4	+ 5.2	80	27	57	25	21	38	35	41	35	68	2.45	— 1.4	11	5,875	s.	39	nw.	19	8	10	13	5.9	T.
Cape Henry	18	9	58	30.09	30.11	+ .08	52.1	+ 5.5	84	29	61	26	22	43	35				4.36	0.0	14	9,873	sw.	40	n.	21	11	11	9	5.3	6.0
Lynchburg	681	83	88	29.37	30.12	+ .07	51.6	+ 6.2	80	18	62	24	21	41	36	46	42	75	2.51	— 1.3	12	3,076	sw.	24	w.	15	10	12	9	5.6	5.3
Mount Weather	1,725	10	54	28.22	30.09	+ .04	43.0	+ 6.2	74	27	52	19	21	34	35	38	33	75	2.02	— 2.0	14	12,117	nw.	61	nw.	19	6	12	13	6.3	0.8
Norfolk	91	102	111	30.04	30.14	+ .11	53.3	+ 5.6	82	29	63	29	21	44	34	48	44	76	4.50	+ 0.2	16	7,660	s.	32	sw.	19	14	5	12	5.2	5.5
Richmond	144	145	153	29.99	30.14	+ .10	52.2	+ 5.3	82	28	63	24	21	42	35				2.96	— 0.8	13	6,678	s.	52	nw.	15	8	12	11	5.9	2.8
Wytheville	2,293	40	47	27.71	30.11	+ .06	48.4	+ 6.1	79	18	59	21	21	38	33	44	43	86	2.66	— 1.8	17	4,117	w.	26	sw.	6	11	8	12	5.6	2.0
S. Atlantic States.							60.2	+ 6.4										79	3.70	— 0.6									4.6	
Asheville	2,255	53	75	27.75	30.12	+ .06	53.2	+ 8.3	83	18	64	26	21	42	41	47	44	79	2.87	— 2.2	9	6,094	se.	32	n.	19	10	10	11	5.5	1.0
Charlotte	773	68	76	29.29	30.13	+ .08	57.6	+ 6.8	82	19	68	30	21	48	34	49	44	68	4.27	— 0.3	12	6,482	sw.	32	sw.	15	10	12	9	5.5	0.9
Hatteras	11	12	47	30.13	30.14	+ .10	55.0	+ 3.6	73	28	62	34	21	48	23	52	50	89	5.77	+ 0.3	16	11,679	sw.	45	ne.	21	15	10	6	4.1	T.
Manteo							55.1		82	19	64	31	22	46					5.36		10		sw.					22	5	4		4.0
Raleigh	376	71	79	29.72	30.13	+ .08	57.0	+ 6.6	85	18	68	24	21	46	35	49	45	72	5.58	+ 1.3	10	5,014	sw.	26	ne.	20	8	14	9	5.4	2.3
Wilmington	78	81	91	30.07	30.15	+ .10	59.4	+ 5.7	84	19	69	31	21	50	33	53	50	82	4.71	+ 1.1	9	7,329	sw.	34	sw.	23	15	11	5	4.3	T.
Charleston	48	14	92	30.09	30.14	+ .08	62.2	+ 5.0	84	16	70	36	21	54	26	57	55	87	2.16	— 1.6	8	9,094	sw.	36	e.	30	17	7	7	3.9	
Columbia, S. C.	351	41	57	29.75	30.13	+ .07	61.6	+ 7.6	85	18	72	33	21	51	36	53	49	71	4.15	+ 0.4	10	6,657	sw.	36	sw.	23	9	13	9	5.5	
Augusta	180	89	97	29.93	30.12	+ .06	63.2	+ 7.3	86	18	74	36	21	52	30	56	52	74	3.89	— 1.0	8	5,300	sw.	38	sw.	23	20	5	6	3.4	
Savannah	65	81	89	30.08	30.15	+ .09	65.2	+ 6.9	86	18	75	38	21	56	35	58	55	83	2.44	— 1.2	4	6,742	sw.	27	e.	30	16	7	8	4.3	
Jacksonville	43	101	129	30.10	30.16	+ .10	67.7	+ 5.8	85	31	77	45	21	59	28	61	58	82	1.16	— 2.4	5	7,727	sw.	68	s.	24	18	9	4	3.6	
Florida Peninsula.							72.4	+ 3.0										81	0.42	— 1.8									2.6	
Jupiter	28	10	48	30.11	30.14	+ .09	72.2	+ 2.8	88	24	78	61	7	66	18	67	65	84	0.67	— 2.4	4	8,857	e.	34	s.	23	10	20	1	4.3	
Key West	22	10	53	30.09	30.11	+ .06	74.8	+ 2.0	84	24	80	63	1	70	14	68	65	78	0.48	— 1.0	2	7,420	e.	27	sw.	25	23	8	0	2.5	
Sand Key	25	41	71	30.08	30.11	+ .06	73.4		82	21	76	62	5	71	12				0.47	— 1.0	4	10,516	e.	31	e.	9	23	7	1	2.2	
Tampa	35	79	96	30.12	30.16	+ .09	70.2	+ 4.3	87	30	80	51	1	60	25	63	60	80	0.08	— 2.7	1	5,733	ne.	35	sw.	24	28	1	2	1.6	
East Gulf States.							64.4	+ 7.1										80	4.62	— 1.2									5.0	
Atlanta	1,174	190	216	28.88	30.12	+ .06	59.7	+ 7.3	83	18	69	32	21	51	27	53	50	76	3.57	— 2.2	9	9,303	w.	34	w.	23	16	11	4	3.8	
Macon	370	55	66	29.74	30.13	+ .07	64.6	+ 9.8	88	18	75	39	21	54	31				6.42	+ 0.9	7	4,007	sw.	31	w.	23	12	12	7	4.6	
Thomasville	273	8	58	29.85	30.14	+ .08	66.6	+ 6.4	87	30	79	40	1	54	36	59	56	80	2.08	— 3.0	5	4,822	s.	26	sw.	20	20	7	4	3.4	
Pensacola	56	79	96	30.06	30.12	+ .06	66.0	+ 4.9	78	28	72	41	21	60	25				3.85	— 1.5	4	7,692	se.	30	s.	22	11	14	6	4.7	
Anniston	741	9	58	29.34	30.14	+ .08	60.8	+ 8.3	86	18	72	32	21	50	35				4.57	— 1.2	8	5,192	s.	25	sw.	18	9	8	14	6.4	
Birmingham	700	11	48	29.35	30.12	+ .06	61.6	+ 6.4	85	18	71	32	21	52	28	55	51	76	4.14	— 1.6	9	6,426	sw.	24	sw.	18	6	12	13	6.4	
Mobile	57	98	106	30.06	30.12	+ .06	66.2	+ 7.1	81	18	74	41	21	59	25	61	59	87	6.87	— 0.3	4	5,481	se.	23	nw.	20	9	17	5	5.1	
Montgomery	223	100	112	29.87	30.12	+ .06	65.2	+ 7.3	87	18	76	35	21	55	31	58	53	73	5.36	— 1.0	7	5,599	sw.	24	sw.	18	9	14	8	5.4	
Meridian	378	84	93	29.69	30.09	+ .04	64.0	+ 7.7	88	18	74	35	21	54	34	58	54	78	3.94	— 1.7	5	5,009	s.	22	s.	23	13	10	8	5.1	
Vicksburg	247	62	74	29.80	30.08	+ .04	64.9	+ 6.7	87	18	73	39	21	56	27	59	57	82	6.76	+ 0.5	8	5,904	s.	27	nw.	23	6	18	7	5.4	
New Orleans	51	88	121	30.03	30.09	+ .05	68.6	+ 6.6	85	13	77	43	21	60	24	62	60	84	3.28	— 2.0	6	6,849	se.	24	nw.	20	12	13	6	4.9	
West Gulf States.							63.9	+ 6.5										77	2.19	— 0.9									5.3	
Shreveport	249	77	84	29.78	30.05	+ .03	64.9	+ 6.7	89	18	74	41	21	56	33	58	54	76	2.64	— 1.9	7	6,410	se.	25	se.	27	9	11	11	5.9	
Bentonville	1,303	11	44	28.64	30.01	.00	54.6	+ 7.3	84	17	66	27	9	43	37				2.28	— 1.5	10	6,580	s.	28	s.	5	12	9	10	5.0	0.5
Fort Smith	457	79	94	29.51	30.00	— .01	59.4	+ 8.1	88	18	70	37	12	49	37	51	44	64	2.91	— 0.7	9	7,250	e.	30	s.	27	8	15	8	5.4	
Little Rock	357	139	147	29.67	30.04	+ .01	61.0	+ 8.3	87	18	70	38	9	52	36	53	47	68	4.31	— 0.6	12	8,985	s.	45	s.	18	12	12	7	4.6	
Corpus Christi	20	48	53	30.00	30.02	+ .04	69.3	+ 4.9	82	18	75	48	10	64	23	64	62	86	0.53	— 1.3	5	10,306	se.	33	se.	28	8	17	6	5.4	
Fort Worth	670	106	114	29.28	29.99	+ .01	63.5	+ 6.9	92	17	74	37	9	53	36				2.95	+ 1.2	7	9,725	s.	37	s.	5	10	13	8	5.0	
Galveston	54	106	112	30.02	30.08	+ .07	66.3	+ 4.0	77	19	70	51	24	62	18	64	63	94	0.69	— 2.2	3	8,934	se.	32	nw.	23	14	8	9	4.9	
Palestine	510	73	79	29.48	30.01	+ .01	65.7	+ 7.2	87	18	74	42	10	57	29	59	56	77	2.24	— 1.2	6	7,930	s.	30	s.	18	5	14	12	6.4	
San Antonio	701	80	91	29.26	29.99	+ .01	67.8	+ 5.6	93	16	78	43	12	57	37	60	56	72	1.31	— 0.4	6	5,489	se.	35	n.	20	11	12	8	5.2	
Taylor	583	55	63	29.40	30.01	+ .02	65.9	+ 6.2	89	16	75	41	24	56	35				2.04	— 0.6	6	9,233	s.	32	sw.	18	11	11	9	5.1	
Ohio Val. and Tenn.							50.7	+ 6.4										73	5.08	+ 0.6									6.7	
Chattanooga	762	106	112	29.31	30.13	+ .07	57.9	+ 6.6	86	18	67	31	21	48	31	51	46	69	3.35	— 2.9	12	5,506	sw.	31	sw.	6	6	9	16	6.7	
Knoxville	1,004	93	100	29.04	30.10	+ .04	55.4	+ 7.2	83	18	66	30	21	45	33	49	44	71	3.25	— 2.3	9	4,961	sw.	34	sw.	6	2	10	19	7.6	0.4
Memphis	399	76	97	29.66	30.09	+ .05	59.6	+ 7.5	85	18	68	38	21	52	36	54	51	78	5.02	— 0.8	11	7,688	sw.	36	sw.	18	4	12	15	6.8	
Nashville	546	79	91	29.52	30.11	+ .06	57.0	+ 7.8	86	18	66	30	21	48	37	50	45	70	4.15	— 1.3	11	5,942	s.	28	s.	26	5	9	17	6.9	T.
Lexington	989	78	102	29.01	30.09	+ .04	49.6	+ 6.2	79	27	58	26	21	41	31				8.17	+ 3.4	15	9,086	s.	46	nw.	13	12	5	14	5.9	3.0
Louisville	525	111	132	29.50	30.09	+ .04	51.4	+ 6.1	80	18	60	29	21	43	31	46	41	72	6.54	+ 2.2	15	6,781	sw.	40	s.	26	4	14	13	6.7	1.6
Evansville	431	72	82	29.59	30.06	+ .02	51.1	+ 6.5	78	18	59	32	9	43	31				3.76	— 0.8	13	6,704	s.	36	s.	26	3	20	8	6.3	2.5
Indianapolis	822	154	164	29.17	30.07	+ .03	44.8	+ 5.2	76	27	54	25	20	36	34	40	36	74	5.12	+ 1.1	10	8,325	s.	47	sw.	6	4	10	17	7.3	T.
Cincinnati	628	152	160	29.40	30.09	+ .04	48.0	+ 5.2	79	27	57	28	3	39	32	43	38	69	3.66	0.0	16	5,315	sw.	36	w.	15	4	13	14	7.0	1.9
Columbus	824	173	224	29.19	30.07	+ .03	44.5	+ 5.3	76	27	53	25	9	36	29	40	36	75	6.03	+ 2.8	14	9,882	sw.	70	w.	15	5	10	16	6.6	1.6
Pittsburg	842	336	352	29.16	30.08	+ .04	44.6	+ 5.1	77	27	54	21	4	35	32	38	33	68	5.22	+ 2.2	14	8,340	sw.	67	w.	15	5	12	14	6.6	3.0
Parkersburg	638	77	84	29.43	30.10	+ .05	48.8	+ 6.5	80	27	58	28	21	40	31	42	37	71	6.21	+ 2.4	18	5,091	s.	48	nw.	15	8	9	14	6.2	T.
Elkins	1,940	41	50	28.02	30.11	+ .06	46.8	+ 7.7	80	27	58	20	21	35	40	41	37	77	5.58	+ 1.5	19	3,521	w.	33	w.	15	8	10	13	6.3	1.0
Lower Lake Region.							55.4	+ 3.1										76	2.92	+ 0.3									7.2	
Buffalo	767	178	206	29.19	30.04	+ .02	33.2	+ 2.0	59	28	40	13	1	26	27	31	28	81	2.59	0.0	17	12,252	sw.	51	sw.	11	2	12	17	7.6	2.1
Canton	448	10	71	29.53	30.03		27.2	— 0.5	59	26	36	— 2	20	18	42				3.04	+ 0.2	17	10,436	sw.	50	sw.	26	4	4	23	8.2	7.5
Oswego	335	76	91	29.67	30.05	+ .04	33.0	+ 1.6	65	26	40	5	1	26	30	30	27	80	2.55	— 0.3	15	9,230	s.	37	se.	6	4	4	23	7.8	7.4
Rochester	523	81	102	29.47	30.06	+ .04	35.1	+ 3.8	73	26	43	14	1	27	33	31	26	74	3.14	+ 0.2	16	7,523	w.	36	sw.	11	3	7	21	7.9	7.9
Syracuse	597	97	113	29.40	30.06	+ .04	34.0	+ 2.6	69	28	42	6	1	26	32				2.55	+ 0.2	20	11,012	s.	52	s.	26	4	5	22	8.0	9.8
Erie	713	92	102	29.26	30.05	+ .03	37.1	+ 4.0	72	26	45	16	1	29	35	33	28	74	2.22	— 0.4	12	8,481	w.	45	sw.	26	8	6	17	6.7	0.2
Cleveland	762	190	201	29.22	30.06	+ .03	38.9	+ 4.7	72	26	48	21	9	30	37	35	30	72	3.70	+ 0.9	14	11,623	s.	56	s.	26	7	8	16	6.6	3.6
Sandusky	629	62	70	29.35	30.04	+ .01	39.9	+ 4.7	73	26	48	23	9	32	35				3.61	+ 1.1	10	7,040	sw.	40	nw.	15	8	8	15	6.3	0.1
Toledo	628	207	246	29.35	30.05	+ .02	39.8	+ 5.0	74	26	48	22	9	31	35	35	31	74	3.35	+ 1.1	11	12,092	sw.	57	sw.	6	8	11	12	6.1	T.
Detroit	730	218	258	29.23	30.05	+ .02	36.1	+ 3.2	74	26	44	17	9	28	39	33	29	80	2.46	+ 0.1	10	11,218	sw.	54	sw.	6	6	9	16	6.9	1.0
Upper Lake Region.							29.8	+ 2.6										77	2.24	0.0									6.7	
Alpena	609	13	92	29.34	30.03	.00	27.2	+ 2.2	53	23	36	3	9	19	32	25	21	79	2.30	+ 0.3	12	8,423	nw.	46	se.	25	6	8	17	6.6	10.3

TABLE I.—*Climatological data for U. S. Weather Bureau stations, March, 1908*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
Up. Lake Reg—Cont.																													
Escanaba	612	40	82	29.34	30.03	— .01	25.7	+ 2.2	50	23	34	— 1	9	18	33	23	20	80	2.99	+ 1.0	15	7,639	n.	31	e.	6	2	15	14	6.9	26.9
Grand Haven	632	54	92	29.32	30.03	.00	33.6	+ 2.8	57	25	40	18	1	27	38	31	27	78	1.96	— 0.6	11	10,414	sw.	42	s.	25	3	15	13	7.0	2.1
Grand Rapids	707	121	162	29.25	30.04	+ .01	35.1	+ 2.1	65	26	43	16	10	27	46	31	27	77	2.44	— 0.1	11	10,002	sw.	48	sw.	6	2	12	17	7.5	0.2
Houghton	668	66	74	29.26	30.01	— .03	23.6	— 0.2	57	30	33	— 8	3	14	45	....	....	....	1.63	— 0.5	19	5,633	e.	30	n.	8	2	11	18	7.3	19.1
Marquette	734	77	116	29.20	30.03	— .01	25.2	+ 1.5	54	30	32	0	25	18	34	23	19	77	3.28	+ 1.2	16	8,408	nw.	36	sw.	30	2	16	13	6.5	33.4
Port Huron	638	70	120	29.32	30.04	+ .01	33.8	+ 4.2	70	26	42	14	9	26	37	30	27	78	1.74	— 0.7	11	9,335	sw.	46	w.	6	7	7	17	6.7	0.1
Sault Sainte Marie	614	40	61	29.32	30.05	+ .02	22.4	+ 1.1	48	30	31	— 4	25	14	34	20	16	81	0.95	— 0.9	10	7,436	w.	39	nw.	15	5	6	20	7.5	7.7
Chicago	823	140	310	29.14	30.04	+ .01	40.6	+ 6.2	71	26	48	21	9	33	36	35	31	74	3.48	+ 0.9	11	11,719	sw.	54	w.	6	8	7	16	6.3	0.1
Milwaukee	681	122	139	29.29	30.05	+ .02	36.0	+ 5.1	74	26	43	15	9	29	35	32	28	77	2.25	— 0.4	9	9,248	w.	41	sw.	6	13	9	9	4.6	0.2
Green Bay	617	49	86	29.32	30.00	+ .04	31.6	+ 4.8	52	26	39	9	9	24	32	28	23	74	2.38	0.0	8	8,871	sw.	38	n.	27	4	14	13	7.0	8.2
Duluth	1,133	11	47	28.75	30.01	— .05	23.2	— 0.9	55	30	32	— 6	16	15	31	20	16	77	1.54	0.0	12	10,760	sw.	47	sw.	30	5	13	13	6.2	15.1
North Dakota.							20.6	— 0.3										80	1.21	+ 0.2									6.6	
Moorhead	940	8	57	29.02	30.08	.00	21.5	+ 0.1	52	12	32	—16	8	11	37	19	17	86	1.14	0.0	15	7,189	nw.	31	nw.	25	7	14	10	5.9	15.5
Bismarck	1,674	8	57	28.22	30.08	+ .02	24.2	+ 2.1	58	30	35	—17	8	13	43	20	15	73	1.35	+ 0.3	15	8,670	nw.	44	nw.	21	4	14	13	6.8	17.2
Devils Lake	1,482	11	44	28.40	30.05	.00	15.2	— 3.3	48	11	27	—26	8	4	39	13	9	79	1.57	+ 0.6	13	9,540	ne.	48	w.	12	10	6	15	5.9	14.3
Williston	1,875	14	56	27.98	30.04	.00	21.4	— 0.2	55	11	32	— 5	7	11	34	19	15	80	0.79	+ 0.1	13	8,224	sw.	48	nw.	12	2	8	21	7.9	6.6
Upper Miss. Valley.							41.1	+ 5.0										72	1.93	— 0.5									6.0	
Minneapolis	.....	102	208	.....	.....	.....	29.3	.....	63	25	38	— 4	8	21	37	.....	.....	...	1.48	— 0.2	8	9,940	w.	40	se.	25	12	10	9	5.2	14.3
St. Paul	837	171	179	29.09	30.03	— .02	29.6	+ 1.4	62	25	38	— 4	8	22	35	26	21	70	1.16	— 0.4	9	8,780	nw.	38	n.	26	9	13	9	5.6	11.7
La Crosse	714	10	49	29.23	30.02	— .02	34.9	+ 4.0	67	25	43	10	9	26	41	.....	.....	....	1.92	+ 0.3	7	4,859	nw.	28	sw.	21	4	12	15	6.6	2.8
Madison	974	70	78	28.95	30.03	— .01	34.6	+ 4.5	61	26	42	13	9	27	35	31	26	74	1.62	— 0.6	9	8,575	nw.	46	sw.	6	6	10	15	6.7	0.1
Charles City	1,015	3	49	28.93	30.04	— .01	34.6	+ 6.2	69	25	43	8	8	26	43	30	27	80	1.66	+ 0.3	7	6,340	nw.	32	se.	25	5	10	16	6.9	1.4
Davenport	606	71	79	29.37	30.04	+ .01	40.2	+ 4.8	71	12	48	19	9	32	39	35	30	71	2.24	0.0	12	6,603	nw.	32	w.	6	11	6	14	5.8	T.
Des Moines	861	84	101	29.10	30.03	— .01	39.8	+ 4.1	80	25	49	15	8	30	51	34	29	71	1.43	— 0.2	8	6,996	sw.	40	sw.	25	8	10	13	6.1	T.
Dubuque	698	100	117	29.28	30.05	+ .01	37.8	+ 4.6	68	12	46	15	9	30	36	33	28	69	1.72	— 0.5	8	5,949	nw.	34	sw.	6	11	8	12	5.9	T.
Keokuk	614	64	77	29.37	30.06	+ .03	44.8	+ 6.9	75	25	56	18	9	34	44	38	32	70	1.76	— 0.6	6	6,552	nw.	39	sw.	6	15	8	8	4.4	
Cairo	356	87	93	29.68	30.07	+ .03	53.6	+ 6.6	82	18	62	33	9	45	34	48	43	71	1.88	— 2.1	14	9,060	s.	40	s.	27	2	11	18	7.6	T.
La Salle	536	56	64	29.47	30.06	+ .03	41.1	+ 4.3	73	26	50	22	9	32	37	.....	.....	....	3.07	+ 0.2	10	7,523	sw.	43	sw.	6	7	8	16	6.5	0.2
Peoria	609	11	45	29.38	30.06	+ .03	42.3	+ 5.3	76	26	52	20	9	32	39	37	32	74	2.50	— 0.5	9	7,729	s.	49	sw.	26	12	8	11	5.6	T.
Springfield, Ill	644	10	92	29.35	30.05	+ .02	45.5	+ 6.4	79	26	56	25	9	35	39	39	34	71	2.21	— 0.9	9	7,493	s.	32	sw.	6	8	10	13	6.0	
Hannibal	534	75	109	29.46	30.05	+ .03	46.2	+ 4.6	79	25	57	22	9	36	46	.....	.....	....	0.94	— 1.8	6	8,186	sw.	44	w.	6	7	10	14	6.2	
St. Louis	567	208	217	29.42	30.04	+ .01	49.8	+ 6.3	79	26	59	28	9	40	38	43	38	68	3.43	0.0	8	8,054	s.	35	nw.	15	10	10	11	5.7	2.7
Missouri Valley.							41.8	+ 5.7										68	1.36	— 0.6									5.7	
Columbia, Mo	784	11	84	29.19	30.03	.00	47.8	+ 6.4	81	25	59	22	9	36	46	.....	.....	....	1.79	— 1.2	7	7,019	s.	40	sw.	6	11	8	12	5.2	
Kansas City	963	116	181	28.98	30.04	+ .02	47.6	+ 6.8	81	27	59	21	9	36	43	40	33	64	0.86	— 2.0	2	10,783	n.	56	s.	5	7	18	6	5.3	
Springfield, Mo	1,324	98	104	28.61	30.02	.00	51.8	+ 8.3	82	5	63	22	9	40	37	45	39	71	4.14	+ 0.1	9	8,834	s.	33	sw.	6	16	6	9	4.5	1.5
Iola	984	11	50	28.98	30.04	+ .03	49.8	+ 7.4	82	27	62	23	9	38	38	.....	.....	....	2.09	— 0.3	6	6,884	ne.	32	sw.	26	5	10	16	6.7	T.
Topeka	.....	85	89	.....	.....	.....	48.2	+ 7.3	83	25	61	19	9	35	46	.....	.....	....	0.68	— 1.6	3	7,310	sw.	39	w.	6	12	14	5	4.7	
Lincoln	1,189	11	84	28.74	30.04	+ .02	41.8	+ 5.8	86	25	52	14	8	31	49	35	27	64	0.74	— 0.6	5	8,543	n.	43	s.	25	10	12	9	5.2	
Omaha	1,105	115	121	28.84	30.05	+ .01	40.6	+ 4.6	84	25	50	12	8	31	49	34	28	66	0.61	— 0.8	5	7,689	n.	40	n.	26	5	11	15	6.6	T.
Valentine	2,598	47	54	27.27	30.04	+ .01	35.4	+ 3.5	80	25	48	— 1	8	22	62	29	23	69	1.19	0.0	10	8,425	nw.	44	nw.	31	7	16	8	5.2	6.2
Sioux City	1,135	96	164	28.81	30.06	+ .01	37.0	+ 4.4	79	25	47	4	8	27	47	.....	.....	....	0.64	— 0.6	5	9,579	nw.	48	n.	25	9	6	16	6.3	1.2
Pierre	1,572	70	75	28 35	30.06	+ .01	33.2	+ 3.7	67	25	44	— 9	8	22	44	28	21	66	1.23	— 0.1	7	7,883	nw.	45	nw.	31	9	11	11	5.7	12.3
Huron	1,306	56	67	28.63	30.07	+ .01	31.4	+ 4.7	80	25	43	—12	8	20	59	26	21	74	1.24	+ 0.2	10	8,453	nw.	38	n.	25	9	6	16	6.1	11.0
Yankton	1,233	49	57	28.69	30.04	— .01	37.0	+ 5.8	84	25	48	— 2	8	26	52	.....	.....	....	1.08	— 0.1	10	7,027	nw.	35	n.	25	7	4	20	6.9	5.2
Northern Slope.							32.0	+ 1.2										67	1.17	+ 0.1									5.9	
Havre	2,505	11	44	27.31	30.02	+ .02	25.6	— 1.7	58	11	37	—19	4	14	44	24	20	81	1.70	+ 1.2	12	8,063	sw.	42	sw.	29	9	16	6	5.1	16.9
Miles City	2,371	26	48	27.45	30.08	+ .06	30.8	+ 2.2	60	11	42	— 2	8	20	42	26	22	76	1.81	+ 1.0	14	4,967	s.	36	n.	11	5	13	13	6.6	11.7
Helena	4,110	8	56	25.76	30.05	+ .04	32.6	+ 1.6	64	15	43	3	5	22	36	26	18	60	0.68	— 0.1	9	6,836	w.	49	w.	13	5	12	14	6.4	8.1
Kalispell	2,962	8	34	26.88	30.00	+ .01	33.6	+ 0.6	58	24	43	7	4	24	34	23	23	71	1.92	+ 0.8	13	4,378	w.	29	sw.	24	7	8	16	6.6	7.3
Rapid City	3,234	46	50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cheyenne	6,088	56	64	23.92	29.97	+ .01	37.2	+ 4.2	68	25	50	9	20	24	49	28	16	48	0.16	— 0.8	2	9,103	nw.	48	w.	13	7	17	7	4.9	1.9
Lander	5,372	26	36	24.57	30.03	+ .04	30.8	— 0.5	67	15	44	— 3	7	17	42	26	18	64	1.49	— 0.1	4	3,588	sw.	32	w.	14	6	15	10	5.7	16.2
Sheridan	3,790	9	47	26.04	30.03	.....	33.0	.....	63	15	46	0	1	20	42	27	20	66	0.67	.....	14	6,173	nw.	48	w.	14	7	13	11	6.1	7.6
Yellowstone Park	6,200	11	48	23.09	30.08	+ .06	25.2	— 1.3	48	16	35	2	8	16	32	22	17	75	1.39	— 0.8	16	6,270	sw.	33	sw.	24	4	7	20	7.6	20.8
North Platte	2,821	11	51	27.06	30.04	+ .04	40.0	+ 4.7	82	25	55	11	8	25	34	32	24	64	0.20	— 0.7	3	6,434	w.	38	n.	14	13	10	8	4.2	1.2
Middle Slope.							48.3	+ 5.8										55	0.36	— 1.1									4.8	
Denver	5,291	129	136	24.66	29.96	+ .01	43.6	+ 4.9	73	25	57	15	9	31	48	33	19	44	0.11	— 0.9	2	5,993	sw.	38	w.	13	11	18	2	4.3	2.1
Leadville	10,248	7	.....	.....	.....	.....	26.2	.....	50	17	38	— 5	8	15	44	.....	.....	.....	1.14	.....	8	.....	nw.	.....	.....	.....	.....	.....	.....	.....	18.9
Pueblo	4,685	80	86	25.23	29.93	+ .01	47.2	+ 6.6	80	16	62	22	10	32	45	35	18	38	0.18	— 0.7	2	7,372	w.	55	w.	5	18	12	1	3.3	1.2
Concordia	1,398	42	50	28.54	30.04	+ .03	46.1	+ 5.4	87	25	59	18	9	33	46	38	30	64	0.15	— 1.3	3	5,665	n.	35	sw.	25	6	22	3	5.0	
Dodge	2,509	44	54	27.37	30.00	+ .03	47.4	+ 5.7	87	25	64	15	9	31	45	37	27	56	0.12	— 0.8	3	7,187	n.	47	se.	25	12	14	5	4.5	0.8
Wichita	1,358	90	120	28.59	30.04	+ .05	50.6	+ 6.5	85	25	64	20	9	37	42	42	34	62	0.80	— 1.4	2	7,298	n.	37	sw.	27	8	15	8	5.5	T.
Oklahoma	1,214	10	47	28.70	29.99	+ .01	55.0	+ 5.8	91	17	67	28	9	43	40	46	39	65	0.82	— 1.6	7	12,917	s.	58	s.	5	6	12	13	6.2	
Southern Slope.							59.6	+ 6.4										53	0.34	— 0.7									4.9	
Abilene	1,788	45	54	28.17	29.98	+ .02	61.9	+ 7.0	95	17	75	30	9	49	42	50	40	56	0.77	— 0.6	7	6,912	s.	34	s.	5	6	11	14	6.4	
Amarillo	3,676	10	49	26.24	29.96	+ .01	52.2	+ 7.2	86	17	68	20	9	36	48	40	30	55	T.	— 0.6	0	9,363	sw.	53	sw.	5	23	6	2	3.1	T.
Del Rio	944	8	57	28.98	29.96	+ .01	67.2	+ 5.5	100	16	81	38	12	54	52	.....	.....	....	0.53	— 1.2	7	5,115	se.	42	w.	22	11	10	10	5.4	
Roswell	3,578	9	57	26.35	29.97	+ .07	57.0	+ 5.7	91	17	75	23	11	39	53	43	30	45	0.01	— 0.4	1	5,779	sw.	42	sw.	5	12	13	6	4.8	
Southern Plateau.							52.6	+ 1.6										41	0.54	— 0.4									3.6	
El Paso	3,762	110	133	26.10	29.93	+ .05	59.4	+ 3.5	84	16	72	34	12	46	39	44	23	30	0.35	0.0	2	9,810	w.	56	w.	5	13	14	4	4.3	
Santa Fe	7,013	33	39	23.22	29.96	+ .07	42.4	+ 3.0	70	17	56	16	9	29	35	33	24	52	0.28	— 0.4	3	7,263	n.	44	sw.	5	17	13	1	3.3	0.6
Flagstaff	6,907	8	57	23.34	29.97	+ .06	38.2	+ 2.3	71	15	52	6	6	24	43	30	19	55	1.94	+ 0.1	4	7,049	sw.	40	ne.	22	12	12	7	4.8	8.4
Phoenix	1,108	50	56	28.83	29.98	+ .07	61.0	+ 0.5	89	15	75	37	8	47	39	47	31	40	0.41	— 0.1	2	3,278	e.	26	nw.	21	14	12	5	3.6	
Yuma	141	9	58	29.85	30.00	+ .06	64.9	+ 0.5	96	16	81	40	23	49	48	49	31	34	0.08	— 0.3	2	5,331	n.	35	w.	26	27	2	2	1.4	
Independence	3,910	11	42	26.01	30.01	+ .07	49.8	+ 0.2	79	15	65	25	3	35	38	38	21	35	0.14	— 1.6	2	6,185	nw.	36	n.	21	18	10	3	3.5	1.0
Middle Plateau.							40.6	+ 0.9										52	0.70	— 0.6									4.0	
Reno	4,532	56	63	25.52	30.11	+ .03	41.2	+ 0.2	75	16	56	15	7	26	44	32	18	47	0.26	— 1.0	2	4,794	w.	27	sw.	30	15	15	1	3.4	3.8
Tonopah	6,089	12	20	24.07	30.10	.....	41.0	+ 5.6	68	16	50	15	7	32	30	33	21	49	0.22	— 1.2	2	7,103	w.	47	nw.	21	19	11	1	3.1	3.0
Winnemucca	4,344	18	56	25.66	30.11	+ .10	38.6	— 1.0	75	15	55	9	7	22	50	31	22	55	0.25	— 0.7	5	5,702	sw.	43	sw.	24	15	11	5	3.9	1.2
Modena	5,479	10	43	24.61	30.01	+ .05	38.8	— 0.4	72	16	53	4	7	25	49	34	27	64	1.10	— 0.3	5	8,679	w.	50	sw.	25	13	9	9	4.5	12.0
Salt Lake City	4,366	105	110	25.64	30.06	+ .08	41.0	— 0.4	71	16	50	21	7	32	30	34	24	55	1.79	— 0.2	7	5,170	nw.	37	s.	25	11	14	6	4.6	13.5
Durango	6,546	18	56	23.64	30.01	+ .09	39.0	+ 1.5	68	16	53	13	8	25	38	30	18	51	1.15	— 0.3	5	4,481	nw.	32	w.	5	10	16	5	4.7	0.6
Grand Junction	4,608	43	51	25.38	29.98	+ .04	44.6	+ 1.1	74	16	58	22	7	31	38	34	19	40	0.14	— 0.7	4	4,349	w.	34	se.	26	15	13	3	3.5	T.
Northern Plateau.							41.7	+ 1.5										61	0.95	— 0.6									6.2	
Baker City	3,471	48	58	26.47	30.11	+ .08	37.6	+ 2.5	65	24	47	17	3	28	35	33	26	65	0.82	— 0.6	14	5,029	s.	27	nw.	20	5	11	15	6.5	7.1
Boise	2,739	78	86	27.24	30.14	+ .11	42.1	— 0.1	72	24	52	24	7	32	33	35	25	55	1.12	— 0.3	13	5,015	se.	38	nw.	20	6	7	18	7.1	1.0
Lewiston	757	10	51	29.24	30.06	+ .03	45.4	+ 1.4	65	24	54	28	6	37	28	.....	.....	....	1.19	— 0.1	11	5,890	e.	45	w.	24	7	4	20	7.1	T.
Pocatello	4,477	46	54	25.49	30.09	+ .08	38.4	+ 1.5	60	16	46	20	8	31	29	32	23	59	0.51	— 1.2	8	8,189	sw.	40	sw.	31	10	13	8	5.4	3.2
Spokane	1,929	101	110	27.96	30.04	+ .03	40.3	+ 1.4	58	23	48	24	28	32	31	35	27	61	0.51	— 1.0	9	5,652	sw.	30	sw.	23	10	13	8	5.3	0.8
Walla Walla †	1,000	71	79	29.91	30.10	+ .08	46.2	+ 2.2	72	24	55	27	4	38	34	41	34	65	1.53	— 0.4	9	5,904	s.	34	sw.	17	8	13	10	5.7	T.
N. Pac. Coast Reg.							44.0	— 0.2										80	5.08	+ 0.2									6.7	
North Head	211	11	56	29.90	30.14	+ .13	44.2	— 0.7	58	19	48	36	17	40	21	43	41	88	6.23	+ 1.0	24	13,333	nw.	74	se.	24	3	11	17	7.3	
Port Crescent	259	12	29	29.83	30.11	+ .13	40.4	— 0.1	54	15	47	26	6	34	22	.....	.....	....	5.82	+ 1.9	19	4,123	ne.	24	sw.	24	1	18	12	6.7	T.
Seattle	123	185	224	30.00	30.13	+ .14	44.2	0.0	61	9	50	32	6	38	28	41	38	81	2.54	— 1.1	16	7,998	s.	46	s.	15	2	15	14	7.1	T.
Tacoma	213	113	120	29.88	30.12	+ .12	43.7	— 0.5	61	9	50	28	6	37	31	41	37	80	5.99	+ 2.0	15	5,435	sw.	38	sw.	24	12	7	12	5.2	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, March, 1908*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.								Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
N. P. Coast Reg—Cont.																													
Tatoosh Island	86	7	57	29.98	30.08	+ .12	43.2	+ 0.3	50	31	47	36	18	40	12	41	38	83	8.64	+ 0.1	24	13,007	s.	54	s.	12	4	6	21	7.9	T.
Portland, Oreg	153	68	106	29.99	30.15	+ .13	46.3	0.0	66	23	53	30	9	39	33	43	38	74	4.39	— 0.8	19	5,376	sw.	31	s.	13	3	19	9	6.6	
Roseburg	510	9	57	29.64	30.20	+ .16	46.1	— 0.5	74	23	57	27	19	35	38	41	37	76	1.98	— 2.0	15	2,395	s.	30	sw.	24	7	11	13	6.2	0.5
Mid. Pac. Coast Reg.							52.9	+ 0.5										67	1.11	— 2.7									5.5	
Eureka	62	62	80	30.15	30.22	+ .16	47.2	— 0.8	63	24	54	33	6	41	24	44	42	85	2.82	— 4.2	14	5,229	n.	40	n.	18	15	12	4	4.1	
Mount Tamalpais	2,375	11	18	27.64	30.14	+ .08	50.1	.....	70	22	56	32	4	44	29	42	35	63	1.19	— 2.1	8	13,460	nw.	72	nw.	26	21	7	3	2.7	2.1
Point Reyes Light	490	7	18	29.58	30.10	.....	50.6	.....	70	22	56	39	4	46	22	....	....	....	0.36	.....	7	16,270	nw.	65	nw.	30	16	12	3	3.4	
Red Bluff	332	80	56	29.75	30.11	+ .07	54.7	+ 0.9	81	22	67	33	5	42	33	46	36	56	0.91	— 2.8	2	5,075	nw.	32	nw.	21	13	14	4	4.7	
Sacramento	69	106	117	30.05	30.12	+ .09	55.4	+ 1.2	78	15	66	37	5	45	33	49	42	63	0.42	— 2.6	3	6,030	se.	33	nw.	21	20	11	0	2.8	
San Francisco	155	200	204	29.97	30.14	+ .08	54.8	+ 2.1	76	22	62	40	6	47	23	47	42	68	0.90	— 2.2	8	4,625	w.	27	ne.	21	20	10	1	2.6	
San Jose	141	78	88	29.98	30.14	.....	52.6	— 1.1	79	23	66	30	7	40	37	....	....	....	1.14	— 2.0	7	4,512	nw.	36	n.	21	23	4	4	2.6	
Southeast Farallon	30	9	17	30.11	30.14	.....	50.5	.....	62	10	54	41	27	48	10	....	....	....	0.42	— 2.7	6	13,375	nw.	50	nw.	17	19	9	3	3.2	
S. Pac. Coast Reg.							66.9	+ 1.3										64	0.57	— 2.9									3.3	
Fresno	330	67	70	29.76	30.12	+ .11	56.2	+ 1.3	83	24	69	33	7	44	33	48	40	62	0.71	— 1.0	4	3,245	w.	20	w.	25	24	4	3	2.1	
Los Angeles	338	116	123	29.70	30.06	+ .04	58.0	+ 2.4	85	13	68	40	5	48	37	49	42	63	0.18	— 2.8	4	3,810	ne.	27	sw.	26	17	7	7	3.8	
San Diego	87	94	102	29.97	30.07	+ .05	56.8	+ 0.6	78	11	64	42	8	50	27	50	44	67	0.61	— 1.1	6	4,127	nw.	23	sw.	26	23	3	5	2.9	
San Luis Obispo	201	47	54	29.90	30.12	+ .06	56.6	+ 2.8	84	15	69	34	5	44	43	49	43	65	0.79	— 3.2	6	4,180	n.	22	w.	31	21	6	4	2.8	
West Indies.																														
Grand Turk	11	6	20	30.07	30.08	+ .06	75.5	.....	84	21	81	65	2	70	....	....	....	....	4.07	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
San Juan	82	48	90	29.94	30.03	+ .01	75.4	.....	87	2	81	64	3	70	20	70	67	75	4.44	+ 2.1	23	10,464	e.	44	nw.	3	14	17	0	3.9	
Panama.																														
Christobal	74	....	....	29.88	29.89	.....	79.7	.....	83	25	82	74	16	77	9	74	72	79	3.53	.....	14	12,352	n.	29	ne.	5	15	14	2	4.1	
Bas Obispo	40	....	....	29.71	29.88	.....	77.9	.....	90	26	86	64	27	70	22	72	70	82	0.41	.....	6	5,902	nw.	24	ne.	5	3	7	21	6.0	
Ancon	.....	.....	.....	29.79	29.86	.....	82.6	.....	96	20	93	69	27	72	25	72	69	74	0.03	.....	1	7,205	nw.	26	nw.	16	10	16	5	4.6	
Alhajuela	.....	.....	.....	.....	.....	.....	78.4	.....	91	29	88	63	27	68	26	....	....	....	0.24	.....	8	4,142	ne.	22	ne.	8	....	....	....	....	
Bohio	.....	.....	.....	.....	.....	.....	78.0	.....	89	19	87	65	27	69	22	....	....	....	1.77	.....	14	3,029	n.	16	nw.	9	....	....	....	....	
Gatun	.....	.....	.....	.....	.....	.....	78.8	.....	88	29	86	66	18	72	18	....	....	....	2.81	.....	15	8,164	n.	27	n.	12	....	....	....	....	

* More than one date.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during March, 1908, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	9–10	.....	.....	0.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.10	.....	.....	.....
Albany, N. Y	6–7	.....	.....	0.31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Alpena, Mich	27–28	.....	.....	1.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Amarillo, Tex	8	.....	.....	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Anniston, Ala	22–23	.....	.....	2.03	.....	.....	.....	.....	.....	.....	.....	.....	0.43	.....	.....	.....	.....	.....	.....	.....	.....
Asheville, N. C	19–20	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.26	.....	.....	.....
Atlanta, Ga	22–23	.....	.....	2.06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.29	.....	.....	.....
Atlantic City, N. J	23	.....	.....	0.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.14	.....	.....	.....
Augusta, Ga	23–24	.....	.....	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.33	.....	.....	.....
Baltimore, Md	5–6	.....	.....	0.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Bentonville, Ark	8	.....	.....	0.99	.....	.....	.....	.....	.....	.....	.....	.....	0.16	.....	.....	.....	.....	.....	.....	.....	.....
Binghamton, N. Y	1–2	.....	.....	0.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.15	.....	.....	.....
Birmingham, Ala	22–23	.....	.....	2.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.43	.....	.....	.....
Bismarck, N. Dak	17–18	.....	.....	0.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Block Island, R. I	18–19	.....	.....	0.96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.28	.....	.....	.....
Boise, Idaho	30	.....	.....	0.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.08	.....	.....	.....
Boston, Mass	15	.....	.....	0.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.23	.....	.....	.....
Buffalo, N. Y	27–28	.....	.....	0.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.20	.....	.....	.....
Cairo, Ill	28–29	.....	.....	0.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.21	.....	.....	.....
Canton, N. Y	26–27	.....	.....	0.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Charles City, Iowa	5–6	.....	.....	0.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Charleston, S. C	24	.....	.....	1.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.51	.....	.....	.....
Charlotte, N. C	22–23	.....	.....	1.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.40	.....	.....	.....
Chattanooga, Tenn	22–23	.....	.....	1.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.33	.....	.....	.....
Cheyenne, Wyo	5	.....	.....	0.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Chicago, Ill	26–27	.....	.....	1.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Cincinnati, Ohio	1	.....	.....	0.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.37	.....	.....	.....
Cleveland, Ohio	1	.....	.....	0.98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.43	.....	.....	.....
Columbia, Mo	7–8	.....	.....	0.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Columbia, S. C	20	.....	.....	1.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.32	.....	.....	.....
Columbus, Ohio	18	.....	.....	0.84	.....	.....	.....	.....	0.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Concord, N. H	29	.....	.....	0.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.20	.....	.....	.....
Corpus Christi, Tex	22–23	.....	.....	0.25	.....	.....	.....	.....	.....	.....	.....	.....	0.06	.....	.....	.....	.....	.....	.....	.....	.....
Davenport, Iowa	27	5:20 p. m.	D. N.	0.54	7:40 p. m.	7:50 p. m.	0.19	0.18	0.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Del Rio, Tex	22–23	.....	.....	0.19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.15	.....	.....	.....
Denver, Colo	21	.....	.....	0.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Des Moines, Iowa	30	.....	.....	0.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.24	.....	.....	.....
Detroit, Mich	15	.....	.....	0.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.24	.....	.....	.....
Dodge, Kans	22	.....	.....	0.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Dubuque, Iowa	30–31	.....	.....	0.74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.24	.....	.....	.....
Duluth, Minn	1	.....	.....	0.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Eastport, Me	15–16	.....	.....	0.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.20	.....	.....	.....
Elkins, W. Va	19	.....	.....	0.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.40	.....	.....	.....
Erie, Pa	1–2	.....	.....	0.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Escanaba, Mich	5–6	.....	.....	1.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Evansville, Ind	28–29	.....	.....	0.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.35	.....	.....	.....
Fort Smith, Ark	8–9	.....	.....	2.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.51	.....	.....	.....
Fort Worth, Tex	8–9	.....	.....	1.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Galveston, Tex	23	.....	.....	0.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.29	.....	.....	.....
Grand Haven, Mich	27	.....	.....	0.81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.43	.....	.....	.....
Grand Rapids, Mich	27–28	.....	.....	1.04	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.40	.....	.....	.....
Green Bay, Wis	5–6	.....	.....	1.28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Hannibal, Mo	27	.....	.....	0.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.22	.....	.....	.....
Harrisburg, Pa	18–19	.....	.....	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.27	.....	.....	.....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Hartford, Conn.	18–19			1.10														*			
Hatteras, N. C.	17	1:50 p. m.	3:15 p. m.	0.80	2:00 p. m.	2:25 p. m.	0.05	0.05	0.15	0.41	0.47	0.62	0.74								
Huron, S. Dak.	5–6			0.87														*			
Indianapolis, Ind.	18	11:00 a. m.	D. N.	1.11	6:23 p. m.	6:36 p. m.	0.04	0.10	0.29	0.36											
Iola, Kans.	7–8			1.15														0.34			
Jacksonville, Fla.	20–21	8:30 p. m.	D. N.	0.82	9:24 p. m.	9:43 p. m.	0.01	0.28	0.48	0.68	0.77										
Jupiter, Fla.	28			0.39														0.35			
Kansas City, Mo.	4			0.48														0.36			
Keokuk, Iowa	17			0.84														*			
Key West, Fla.	24–25			0.48														0.40			
Knoxville, Tenn.	19–20			0.88														0.25			
La Crosse, Wis.	5–6			1.21														0.52			
La Salle, Ill.	27			0.87														0.39			
Lexington, Ky.	31–1†	3:40 p. m.	4:15 a. m.	2.51	9:38 p. m.	10:27 p. m.	0.65	0.09	0.15	0.23	0.32	0.34	0.40	0.51	0.59	0.71	0.76				
Lincoln, Nebr.	5			0.35														*			
Little Rock, Ark.	28–29	6:25 p. m.	D. N.	2.42	7:24 p. m.	8:11 p. m.	0.15	0.07	0.20	0.42	0.56	0.63	0.67	0.71	0.75	0.86					
Los Angeles, Cal.	25–26			0.16						0.05											
Louisville, Ky.	31	7:14 p. m.	D. N.	0.99	9:00 p. m.	9:25 p. m.	0.34	0.15	0.40	0.46	0.55	0.62									
Lynchburg, Va.	5–6			0.51									0.14								
Macon, Ga.	23–24	2:40 p. m.	6:00 a. m.	3.03	3:31 p. m.	4:28 p. m.	0.05	0.32	0.44	0.51	0.60	0.69	0.76	0.85	0.96	1.01	1.06	1.30			
Madison, Wis.	27			0.56														0.27			
Marquette, Mich.	5–6			1.04														*			
Memphis, Tenn.	2	D. N.	D. N.	0.70	12:18 a. m.	12:42 a. m.	T.	0.06	0.12	0.23	0.39	0.55									
Meridian, Miss.	22–23			2.34														0.56			
Milwaukee, Wis.	27	11:45 a. m.	10:30 p. m.	1.26	7:50 p. m.	8:22 p. m.	0.13	0.12	0.15	0.30	0.35	0.45	0.53	0.59							
Minneapolis, Minn.	5–6			0.88														0.14			
Mobile, Ala.	23	12:22 p. m.	D. N.	3.53	12:29 p. m.	1:41 p. m.	0.06	0.17	0.34	0.60	0.82	0.97	1.03	1.09	1.13	1.16	1.19	1.30	1.56		
Montgomery, Ala.	23–24	11:00 a. m.	6:45 a. m.	2.15	11:42 a. m.	12:41 p. m.	0.01	0.26	0.39	0.45	0.49	0.50	0.51	0.52	0.57	0.58	0.67	0.84			
Mount Weather, Va.	5–6			0.58														*			
Nantucket, Mass.	15			0.23														0.23			
Nashville, Tenn.	2			1.22														0.53			
New Haven, Conn.	18–19			1.39														0.34			
New Orleans, La.	23	9:00 a. m.	3:45 p. m.	2.59	10:58 a. m.	11:11 a. m.	0.44	0.21	0.51	0.63											
New York, N. Y.	18–19			0.63														0.16			
Norfolk, Va.	23–24			1.34														0.32			
Northfield, Vt.	15			0.15														0.09			
North Head, Wash.	12–13			1.66														0.18			
Oklahoma, Okla.	27			0.17					0.15												
Omaha, Nebr.	4–5			0.31														0.14			
Palestine, Tex.	20			0.28					0.18												
Parkersburg, W. Va.	28–29			1.23														0.59			
Pensacola, Fla.	23			1.80					0.40												
Peoria, Ill.	17–18			1.43														*			
Philadelphia, Pa.	18–19			0.94														0.33			
Pittsburg, Pa.	18–19			1.49														*			
Portland, Me.	1–2			0.82														0.12			
Portland, Oreg.	14–15			1.86														0.19			
Pueblo, Colo.	5			0.10														*			
Raleigh, N. C.	23–24	8:30 p. m.	7:35 a. m.	1.44	8:49 p. m.	9:47 p. m.	0.04	0.11	0.18	0.22	0.29	0.34	0.42	0.63	0.69	0.71	0.81	1.00			
Richmond, Va.	31			0.82														0.22			
Rochester, N. Y.	27–28			0.83														0.48			
Sacramento, Cal.	1			0.30														0.20			
St. Louis, Mo.	1			0.46														0.39			
St. Paul, Minn.	5–6			0.68														*			
Salt Lake City, Utah.	5			0.82														*			
San Antonio, Tex.	20			0.60														0.21			
San Diego, Cal.	3–4			0.31						0.05											
Sandusky, Ohio.	5–6			1.47														*			
San Francisco, Cal.	4–5			0.41														0.25			
Savannah, Ga.	24	12:46 p. m.	2:30 p. m.	1.01	12:54 p. m.	1:30 p. m.	0.02	0.33	0.50	0.55	0.60	0.68	0.72	0.85	0.86						
Scranton, Pa.	18–19			1.44														0.65			
Seattle, Wash.	12–13			0.96														0.13			
Shreveport, La.	22–23			1.21														0.28			
Spokane, Wash.	14–15			0.16														*			
Springfield, Ill.	27			0.45				0.25													
Springfield, Mo.	30–31			1.73														*			
Syracuse, N. Y.	1–2			1.09														*			
Tampa, Fla.	24			0.08														0.08			
Taylor, Tex.	9–10			1.54														0.36			
Thomasville, Ga.	23–24			1.14				0.42													
Toledo, Ohio	28			0.51														0.44			
Topeka, Kans.	30–31			0.40														0.11			
Valentine, Nebr.	16–17			0.52														*			
Vicksburg, Miss.	23	D. N.	1:35 p. m.	2.45	4:45 a. m.	5:12 a. m.	0.61	0.13	0.35	0.48	0.53	0.64	0.71								
Washington, D. C.	19			0.21														0.15			
Wichita, Kans.	30			0.75														0.22			
Wilmington, N. C.	22–23	7:19 p. m.	9:55 a. m.	1.36	7:50 a. m.	8:26 a. m.	0.68	0.10	0.20	0.35	0.40	0.46	0.52	0.63							
Wytheville, Va.	19			0.36														0.24			
Yankton, S. Dak.	5–6			0.69														*			
San Juan, P. R.	3	7:30 p. m.	D. N.	1.12	7:34 p. m.	8:17 p. m.	T.	0.13	0.22	0.28	0.42	0.54	0.63	0.78	0.87	0.92					

*Self-register not working. †April.

TABLE III.—*Data furnished by the Canadian Meteorological Service, March, 1908.*

Stations.	Pressure, in inches.			Temperature.				Precipitation.		
	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean.	Departure from normal.	Mean maximum.	Mean minimum.	Total.	Departure from normal.	Total snowfall.
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
St. Johns, N. F	29.74	29.88	.00	25.9	— 1.8	31.8	20.1	5.60	+0.84	28.2
Sydney, C. B. I	29.96	30.00	+.12	26.6	+ 0.4	35.4	17.7	5.77	+0.84	30.5
Halifax, N. S	29.94	30.05	+.11	30.6	+ 1.6	37.6	23.6	3.19	−2.27	7.7
Grand Manan, N. B	29.97	30.02	+.09	31.2	+ 1.4	38.6	23.9	3.01	−1.27	6.4
Yarmouth, N. S	29.99	30.06	+.11	31.9	+ 1.1	38.2	25.5	2.74	−2.11	6.9
Charlottetown, P. E. I	29.96	30.00	+.10	25.6	+ 0.2	32.9	18.4	3.95	+0.74	16.7
Chatham, N. B	30.00	30.03	+.13	24.5	+ 1.5	35.6	13.5	2.31	−1.16	17.3
Father Point, Que	29.97	30.00	+.10	20.4	+ 0.1	29.3	11.5	2.50	−0.23	21.3
Quebec, Que	29.68	30.02	+.06	21.2	0.0	29.6	12.8	5.52	+2.26	31.1
Montreal, Que	29.80	30.02	+.02	25.6	+ 1.8	33.2	18.1	3.75	−0.04	12.1
Rockliffe, Ont	29.40	30.03	+.02	20.8	+ 1.8	33.3	8.3	0.95	−1.11	8.9
Ottawa, Ont	29.74	30.08	+.07	24.3	+ 2.8	32.0	16.6	3.72	+1.00	15.3
Kingston, Ont	29.74	30.06	+.05	28.0	+ 2.4	34.8	20.2	2.04	−0.60	4.9
Toronto, Ont	29.65	30.05	+.03	31.4	+ 4.1	39.0	23.9	1.68	−0.96	6.2
White River, Ont	.....	.....	.....	12.0	— 3.0	.....	.....	1.80	.....	.....
Port Stanley, Ont	29.39	30.05	+.02	31.8	+ 4.6	38.7	24.9	1.88	−1.00	3.6
Southampton, Ont	29.29	.....	.....	28.2	+ 3.5	36.7	19.7	2.06	−0.59	10.1
Parry Sound, Ont	29.30	30.02	.00	25.6	+ 4.5	35.4	15.8	1.56	−0.67	5.5
Port Arthur, Ont	29.30	30.03	−.02	20.6	+ 3.8	32.5	8.7	0.57	−0.40	5.7
Winnipeg, Man	29.21	30.09	.00	9.6	− 2.7	21.7	− 2.5	1.83	+0.80	18.3
Minnedosa, Man	28.15	30.06	.00	11.4	− 1.1	23.7	− 0.8	0.72	+0.07	7.1
Regina, Sask	27.96	.....	.....	11.5	− 3.4	22.6	0.3	1.76	+0.99	17.6
Medicine Hat, Alberta	.....	.....	.....	24.9	− 2.6	36.1	13.7	0.45	−0.31	4.5
Swift Current, Sask	27.39	30.08	+.05	16.9	− 5.1	26.9	6.9	1.26	+0.45	12.6
Calgary, Alberta	26.34	30.00	+.05	22.0	− 4.2	33.9	10.2	0.55	−0.17	3.7
Banff, Alberta	25.26	30.01	+.07	22.0	.....	32.2	11.8	1.58	+0.17	14.7
Edmonton, Alberta	27.63	30.01	+.05	17.1	− 7.1	29.0	5.2	1.17	+0.45	11.7
Prince Albert, Sask	.....	.....	.....	10.0	.....	.....	.....	0.60	.....	.....
Battleford, Sask	28.25	30.09	+.03	9.0	− 4.1	21.4	− 3.4	1.66	+1.20	16.6
Kamloops, B. C	.....	.....	.....	36.3	+ 0.2	44.6	27.9	0.29	−0.28	....
Victoria, B. C	29.97	30.07	+.10	43.7	+ 1.8	49.6	37.7	4.58	+1.46	....
Barkerville, B. C	25.58	29.99	+.11	22.2	− 3.9	29.4	15.0	5.75	+3.86	....
Hamilton, Bermuda	30.08	30.25	+.17	64.2	+ 2.0	69.7	58.8	8.98	+3.85	....
Dawson, Yukon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE IV.—*Heights of rivers referred to zeros of gages, March, 1908.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Republican River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Clay Center, Kans	42	18	6.7	1,2	5.8	27–31	6.1	0.9
Smoky Hill-Kansas River.								
Abilene, Kans	254	22	0.7	5	0.3	{10,17,18,} {24,29}	0.4	0.4
Manhattan, Kans	160	18	4.0	1	3.1	24–31	3.4	0.9
Topeka, Kans	87	21	7.1	1	5.6	28,29	6.1	1.5
Missouri River.								
Townsend, Mont. (a)	2,504	11	5.0	19	4.3	29–31	4.5	0.7
Fort Benton, Mont. (a)	2,285	12	3.3	18	2.6	26–29	2.9	0.7
Bismarck, N. Dak	1,909	14	6.2	31	3.6	2–4	4.4	2.6
Pierre, S. Dak. (16)	1,114	14	1.9	21,22	0.6	26,29	1.2	1.3
Sioux City, Iowa	784	17	8.1	13	5.6	11	7.0	2.5
Blair, Nebr	705	15	7.5	2,14	6.1	17–19	6.7	1.4
Omaha, Nebr	669	18	10.5	1	8.3	6	9.3	2.2
Plattsmouth, Nebr	641	17	4.6	3,22	3.4	6,18,19	3.9	1.2
St. Joseph, Mo	481	10	3.9	16	2.3	21,22	3.0	1.6
Kansas City, Mo	388	21	10.6	17	9.1	21	9.9	1.5
Glasgow, Mo	231	18	8.1	2,5	6.3	24	7.3	1.8
Boonville, Mo	199	20	10.1	5	8.6	24	9.3	1.5
Hermann, Mo	103	24	13.3	9	7.2	26	9.8	6.1
Minnesota River.								
Mankato, Minn	127	18	6.0	17	3.2	8–10	4.7	2.8
St. Croix River.								
Stillwater, Minn. (32)	23	11	.....	.....	.....	.....	.....	.....
Illinois River.								
La Salle, Ill	197	18	28.8	8	21.3	31	24.6	7.5
Peoria, Ill	135	14	22.2	10	17.1	1	19.6	5.1
Conemaugh River.								
Johnstown, Pa	64	7	16.7	19	2.5	1	5.7	14.2
Allegheny River.								
Warren, Pa	177	14	10.0	16	1.6	1	5.7	8.4
Parker, Pa	73	20	12.9	19	2.3	1	7.7	10.6
Freeport, Pa	29	20	26.7	19	5.6	1	13.7	21.1
Springdale, Pa	17	—	31.7	20	8.9	1	17.8	22.8
Youghiogheny River.								
Confluence, Pa	59	10	9.0	19	1.6	1,28	4.3	7.4
West Newton, Pa	15	23	17.8	19	2.0	1	6.4	15.8
Monongahela River.								
Fairmont, W. Va	119	25	23.1	2	15.1	26	17.4	8.0
Greensboro, Pa	81	18	18.5	2	8.4	28	11.4	10.1
Lock No. 4, Pa	40	28	24.0	3	9.8	28	14.6	14.2
Muskingum River.								
Zanesville, Ohio	70	25	26.3	4	11.0	28	17.5	15.3
Little Kanawha River.								
Creston, W. Va	38	20	14.2	10	3.5	28	6.4	10.7
New-Great Kanawha River.								
Hinton, W. Va	133	14	7.9	7	3.2	1	4.8	4.7
Charleston, W. Va	58	30	18.4	8	6.2	1	10.1	12.2
Scioto River.								
Columbus, Ohio	110	17	17.0	2	3.4	27,28	7.7	13.6
Licking River.								
Falmouth, Ky	30	25	19.5	31	4.0	16,17,25	8.8	15.5
Kentucky River.								
Beattyville, Ky	254	30	11.5	3	1.6	28	4.9	9.9
Frankfort, Ky	65	31	13.5	4	7.6	1	9.9	5.9
Wabash River.								
Terre Haute, Ind	171	16	22.9	10,11	9.0	30,31	16.2	13.9
Mount Carmel, Ill	75	15	23.5	15	13.4	31	19.3	10.1
Cumberland River.								
Burnside, Ky	518	50	22.3	3	5.9	29	10.8	16.4
Celina, Tenn	383	45	24.1	5	9.6	29	14.7	14.5
Carthage, Tenn	308	40	20.8	5	8.0	1	13.0	12.8
Nashville, Tenn	193	40	25.3	6	12.3	1	19.1	13.0
Clarksville, Tenn	126	43	27.4	7	12.0	2	21.6	15.4
Clinch River.								
Speers Ferry, Va	156	20	6.8	6	1.0	28,29	3.1	5.8
Clinton, Tenn	52	25	13.8	26	8.3	31	10.7	5.5
South Fork Holston River.								
Bluff City, Tenn	35	12	5.1	6	2.0	30,31	3.0	3.1
Holston River.								
Rogersville, Tenn	103	14	6.6	7	3.3	1	4.5	3.3
French Broad River.								
Asheville, N. C	144	4	3.0	24	0.4	18,19	1.1	2.6
Dandridge, Tenn	46	12	6.7	25	2.1	1	3.3	4.6
Tennessee River.								
Knoxville, Tenn	635	12	11.0	25	3.3	1	6.2	7.7
Loudon, Tenn	590	25	9.5	25	3.8	1	5.8	5.7
Kingston, Tenn	556	25	10.7	25	4.9	1	6.9	5.8
Chattanooga, Tenn	452	33	16.7	26	7.3	2	10.1	9.4
Bridgeport, Ala	402	24	13.7	26	5.7	2	8.4	8.0
Guntersville, Ala	349	31	21.4	27	9.8	3,4	13.6	11.6
Florence, Ala	255	16	13.5	25–27	6.3	3	8.7	7.2
Riverton, Ala	225	26	22.7	26	10.3	3	14.4	12.4
Johnsonville, Tenn	95	21	22.4	30	13.2	11	16.2	9.2
Ohio River.								
Pittsburg, Pa	966	22	27.3	20	4.2	1	13.5	23.1
Coraopolis, Pa	956	25	27.6	20	5.9	1	13.6	21.7
Beaver Dam, Pa	937	27	38.1	20	8.7	1	20.7	29.4
Wheeling, W. Va	875	36	39.6	21	9.2	1	22.0	30.4
Parkersburg, W. Va	785	36	38.6	21	12.0	1	25.3	26.6
Point Pleasant, W. Va	708	39	43.7	10	14.3	1	31.3	29.4
Huntington, W. Va	660	50	47.8	10	19.3	1	35.9	28.5
Catlettsburg, Ky	651	50	48.7	10	18.8	1	36.8	29.9
Portsmouth, Ohio	612	50	50.9	11	19.6	1	38.7	31.3
Maysville, Ky	559	50	49.9	11	19.3	1	38.5	30.6
Cincinnati, Ohio	499	50	53.4	11,22	21.7	1	41.9	31.7
Madison, Ind	413	46	44.8	12	19.8	1	36.0	25.0
Louisville, Ky	367	28	28.0	12	8.4	1	18.3	19.6
Evansville, Ind	184	35	41.5	15	26.5	3	35.9	15.0
Mount Vernon, Ind	148	35	41.9	16	29.1	4	36.5	12.8
Paducah, Ky	47	40	40.4	18,19	33.1	6	36.7	7.3
Cairo, Ill	1	45	45.6	18	40.0	7	42.7	5.6
Neosho River.								
Iola, Kans	262	10	1.2	9	− 0.1	30	0.3	1.3
Oswego, Kans	184	20	14.0	9	0.6	24–29	1.9	13.4
Fort Gibson, Okla	3	22	17.5	11,12	10.0	29–31	12.0	7.5
Canadian River.								
Calvin, Okla	99	10	4.0	14	2.9	28	3.4	1.1
Black River.								
Blackrock, Ark	67	12	20.8	1	11.0	28,31	16.0	9.8
White River.								
Calicorock, Ark	272	18	12.2	13	2.4	28,29	5.3	9.8
Batesville, Ark	217	18	14.0	13	4.3	28	7.5	9.7
Clarendon, Ark	75	30	28.0	4,5	26.5	31	27.3	1.5
Arkansas River.								
Wichita, Kans	832	10	− 1.0	1	− 1.9	26–31	−1.5	0.9
Tulsa, Okla	551	16	7.3	11	3.5	29–31	4.4	3.8
Webbers Falls, Okla	465	23	13.0	12	5.2	26–31	7.8	7.8
Fort Smith, Ark	403	22	15.7	13	4.4	24,26	8.2	11.3
Dardanelle, Ark	256	21	14.8	14	4.3	28	8.6	10.5
Little Rock, Ark	176	23	17.0	1	5.9	28	10.9	11.1
Pine Bluff, Ark	121	25	18.8	2	8.8	28	13.8	10.0
Yazoo River.								
Greenwood, Miss	175	38	32.5	1,2	27.0	22	29.6	5.5
Yazoo City, Miss	80	25	26.0	24	22.7	1	24.3	3.3
Ouachita River.								
Camden, Ark	304	39	20.7	31	8.1	22	11.5	12.6
Monroe, La	122	40	33.3	1	27.4	22	30.2	5.9
Red River.								
Denison, Tex	768	22	5.6	30	0.7	27	2.0	4.9
Arthur City, Tex	688	27	18.0	31	7.6	27	10.2	10.4
Fulton, Ark	515	28	20.0	13,14	9.2	28,29	13.8	10.8
Shreveport, La	327	29	12.3	15	4.4	31	8.5	7.9
Alexandria, La	118	33	20.8	1	14.4	31	18.0	6.4

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Fort Ripley, Minn. (22)	2,082	10						
St. Paul, Minn. (15)	1,954	14	5.7	30, 31	3.4	18	4.6	2.3
Red Wing, Minn. (10)	1,914	14	3.7	30, 31	1.2	11	2.8	2.5
Reeds Landing, Minn.	1,884	12	3.5	30, 31	0.6	2-6	2.0	2.9
La Crosse, Wis. (11)	1,819	12	5.1	16, 17	3.9	23-25	4.4	1.2
Prairie du Chien, Wis. (16)	1,759	18	5.7	18	5.0	25-31	5.2	0.7
Dubuque, Iowa. (4)	1,699	18	7.3	7	5.0	27-30	6.1	2.3
Clinton, Iowa	1,629	16	6.9	8	4.8	27	5.9	2.1
Leclaire, Iowa(5)	1,609	10	4.2	8	2.5	27	3.3	1.7
Davenport, Iowa	1,593	15	10.5	1	5.0	27, 28	6.9	5.5
Muscatine, Iowa	1,562	16	10.3	1	6.0	28	8.0	4.3
Galland, Iowa	1,472	8	5.1	11, 12	3.0	30	4.1	2.1
Keokuk, Iowa	1,463	15	8.8	12, 15	5.1	30	7.1	3.7
Warsaw, Ill	1,458	18	11.8	12	7.9	29	10.3	3.9
Hannibal, Mo	1,402	13	9.9	14	6.2	30, 31	8.2	3.7
Grafton, Ill	1,306	23	14.8	15, 16	12.1	31	13.7	2.7
St. Louis, Mo	1,264	30	21.0	10	14.8	31	17.9	6.2
Chester, Ill	1,189	30	18.5	11, 12	12.8	30	15.6	5.7
Cape Girardeau, Mo.	1,128	28	23.9	12-14	17.8	29	21.0	6.1
New Madrid, Mo.	1,003	34	36.6	20, 21	32.8	8, 9	34.7	3.8
Luxora, Ark	905	33	30.1	22, 23	27.1	10, 11	28.7	3.0
Memphis, Tenn	843	33	35.6	23-25	32.7	12	34.4	2.9
Helena, Ark.	767	42	45.2	26, 27	42.7	1	43.9	2.5
Arkansas City, Ark.	635	42	48.2	28-31	44.2	1	47.1	4.0
Greenville, Miss.	595	42	42.5	28-31	37.5	1	41.1	5.0
Vicksburg, Miss.	474	45	46.9	31	41.0	1	45.0	5.9
Natchez, Miss.	373	46	46.7	31	40.0	1	44.1	6.7
Baton Rouge, La.	240	35	35.0	30, 31	29.1	1	32.4	5.9
Donaldsonville, La	188	28	27.8	31	23.1	1	25.8	4.7
New Orleans, La.	108	16	17.7	30, 31	14.9	1	16.5	2.8
Atchafalaya River.								
Simmesport, La.	127	33	39.4	31	33.9	1	36.8	5.5
Melville, La.	103	31	36.5	31	33.2	1	35.0	3.3
Hudson River.								
Troy, N. Y.	154	14	10.7	30	5.8	5	7.3	4.9
Albany, N. Y.	147	12	14.4	15	5.5	23	8.2	8.9
Delaware River.								
Hancock (E. Branch), N. Y.	287	12	9.3	29	3.5	1, 7-9	5.1	5.8
Hancock (W. Branch), N. Y.	287	10	8.5	14	3.4	11	5.6	5.1
Port Jervis, N. Y.	215	14	9.1	29	1.4	10	4.2	7.7
Phillipsburg, N. J.	146	26	11.7	30	3.5	7	6.7	8.2
Trenton, N. J.	92	18	7.8	30	2.5	14	4.5	5.3
North Branch Susquehanna.								
Binghamton, N. Y.	183	14	12.5	16	2.9	10, 11, 16	6.4	9.6
Wilkes-Barre, Pa.	60	17	21.0	16	6.0	3	12.1	15.0
West Branch Susquehanna.								
Williamsport, Pa.	39	20	17.6	20	2.4	2	9.2	15.2
Susquehanna River.								
Harrisburg, Pa.	69	17	16.0	20	3.8	3	8.9	12.2
Shenandoah River.								
Riverton, Va.	58	22	3.2	4	− 0.3	31	1.1	3.5
Potomac River.								
Cumberland, Md.	290	8	9.6	9	3.0	1	5.2	6.6
Harpers Ferry, W. Va.	172	18	12.8	10	3.3	31	7.1	9.5
James River.								
Lynchburg, Va.	260	20	6.6	7	1.5	19	3.4	5.1
Columbia, Va.	167	18	12.2	8	6.5	31	8.3	5.7
Richmond, Va.	111	10	4.6	8	0.8	29	1.9	3.8
Roanoke River.								
Clarksville, Va	196	12	5.6	25	1.4	20	2.3	4.2
Weldon, N. C.	129	30	33.1	25	13.4	20	16.8	19.7
Tar River.								
Greenville, N. C.	21	22	16.2	30	7.9	7, 10, 11	10.6	8.3
Deep River.								
Moncure, N. C.	171	25	22.3	24	8.4	19	10.4	13.9
Cape Fear River.								
Fayetteville, N. C.	112	38	41.7	26	7.1	5	16.9	34.6
Pedee River.								
Cheraw, S. C (b)	149	27	30.6	25	4.8	20	11.5	25.8
Smiths Mills, S. C.	51	16	16.2	31	10.9	14	12.9	5.3
Lynch Creek.								
Effingham, S. C.	35	12	11.8	31	5.0	18, 19	7.4	6.8
Black River.								
Kingstree, S. C (b)	45	12	7.5	1	3.0	24	4.6	4.5

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Catawba-Wateree River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Mount Holly, N. C.	143	15	6.6	24	2.0	30, 31	2.6	4.6
Catawba, S. C	107	11	11.9	25	2.8	19	4.2	9.1
Camden, S. C.	37	24	28.6	25	9.6	11	13.1	19.0
Congaree River.								
Columbia, S. C	52	15	17.0	25	1.5	8	4.3	15.5
Savannah River.								
Calhoun Falls, S. C.	347	15	10.1	24	2.9	18, 19	4.1	7.2
Augusta, Ga.	268	32	29.8	25	9.4	19	12.6	20.4
Oconee River.								
Dublin, Ga	79	30	21.4	28	2.9	21, 22	7.6	18.5
Ocmulgee River.								
Macon, Ga.	203	18	19.2	24	4.3	21	7.2	14.9
Abbeville, Ga.	96	11	15.9	30	6.3	20-22	9.1	9.6
Flint River.								
Montezuma, Ga.	152	20	17.8	27	5.2	22	8.1	12.6
Albany, Ga.	90	20	23.5	27	4.1	21	9.2	19.4
Bainbridge, Ga.	29	22	24.3	29	8.1	21, 22	12.7	16.2
Chattahoochee River.								
West Point, Ga	239	20	12.4	25	3.7	21	5.3	8.7
Eufaula, Ala	90	40	42.0	25	4.6	14	11.7	37.4
Alaga, Ala.	30	25	36.5	26	7.9	20-22	13.9	28.6
Coosa River.								
Rome, Ga.	266	30	22.0	25	3.2	17-19	6.2	18.8
Gadsden, Ala.	162	22	19.1	26	4.1	20	8.2	15.0
Lock No. 4, Ala.	113	17	15.2	26	3.5	19, 20	7.1	11.7
Wetumpka, Ala	12	45	35.0	27	8.0	21	15.4	27.0
Alabama River.								
Montgomery, Ala.	323	35	35.7	27	5.7	21	13.2	30.0
Selma, Ala	246	35	39.4	28	7.3	22	16.0	32.1
Black Warrior River.								
Tuscaloosa, Ala.	90	43	52.7	25	9.8	20	22.9	42.9
Tombigbee River.								
Columbus, Miss	316	33	21.0	27, 28	1.0	20	8.7	20.0
Demopolis, Ala.	168	35	50.1	1	8.4	22	29.2	41.7
Pascagoula River.								
Merrill, Miss.	78	20	17.8	1	5.9	22	11.1	11.9
Pearl River.								
Columbia, Miss.	110	18	18.2	1	5.0	21, 22	11.1	13.2
Sabine River.								
Logansport, La.	315	25	22.1	1	9.1	10	13.9	13.0
Neches River.								
Beaumont, Tex.	18	10	5.1	1	1.0	21	3.0	4.1
Trinity River.								
Dallas, Tex.	320	25	20.4	11	5.9	8	9.0	14.5
Long Lake, Tex.	211	35	26.6	1	7.0	31	15.6	19.6
Liberty, Tex	20	25	24.4	1, 2	10.4	12	16.9	14.0
Brazos River.								
Waco, Tex.	285	22	5.8	11	3.7	7-9	4.2	2.1
Hempstead, Tex	140	40	14.0	1	2.8	31	7.7	11.2
Booth, Tex	61	39	7.7	18	5.3	4-8, 28-31	6.0	2.4
Colorado River.								
Austin, Tex.	214	18	2.8	11, 12	1.4	7, 9, 31	1.7	1.4
Columbus, Tex.	98	24	8.3	16	6.3	10-14	6.8	2.0
Red River of the North.								
Moorhead, Minn. (10)	284	26	12.8	31	8.7	1	11.0	4.1
Snake River.								
Lewiston, Idaho	144	24	11.0	16	2.1	10, 11	4.6	8.9
Riparia, Wash.	67	30	11.3	17	2.9	8, 11-13	5.3	8.4
Columbia River.								
Wenatchee, Wash	473	40	6.6	26-31	3.7	1	5.1	2.9
Umatilla, Oreg	270	25	8.9	17	1.0	13	3.7	7.9
The Dalles, Oreg.	166	40	14.1	18	0.9	10	5.3	13.2
Willamette River.								
Albany, Oreg.	118	20	13.8	18	3.6	10-13	5.9	10.2
Portland, Oreg.	12	15	14.6	18	1.0	12	6.2	13.6
Sacramento River.								
Red Bluff, Cal.	265	23	6.7	2	3.8	31	5.2	2.9
Colusa, Cal	156	28	14.8	3	10.3	31	12.8	4.5
Knights Landing, Cal.	99	18	12.6	19, 21	10.7	31	11.9	1.9
Sacramento, Cal.	64	25	17.5	19	15.8	4	16.8	1.7
San Joaquin River.								
Pollasky, Cal.	203	10	1.5	19	0.3	8-10	0.9	1.2
Firebaugh, Cal	148	12	3.9	19, 20	1.0	31	2.5	2.9
Lathrop, Cal.	49	14	8.9	27	5.0	1	7.2	3.9

Figures denote number of days frozen. (a) For 16 days only. (b) 2 days missing.

Honolulu, T. H., latitude 21° 19′ north, longitude 157° 30′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. March, 1908.

Day.	Pressure, in inches.*		Air temperature, degrees Fahrenheit.				Moisture.				Wind, in miles per hour.				Precipitation, inches.		Clouds.					
							8 a. m.		8 p. m.		8 a. m.		8 p. m.				8 a. m.			8 p. m.		
	8 a. m.	8 p. m.	8 a. m.	8 p. m.	Maximum.	Minimum.	Wet.	Relative humidity.	Wet.	Relative humidity.	Direction.	Velocity.	Direction.	Velocity.	8 a. m.	8 p. m.	Amount.	Kind.	Direction, from.	Amount.	Kind.	Direction, from.
							°	%	°	%												
1	30.03	30.01	74.0	71.0	79	68	65.0	61	65.0	72	e.	7	ne.	3	T.	0.00	4	Cu.	e.	0	0	0
2	30.07	30.03	74.0	72.5	79	67	65.1	61	66.0	71	se.	3	e.	10	0.00	0.03	Few	Cu.	se.	8	N.	e.
3	30.04	30.00	73.0	69.5	78	68	62.4	55	65.0	79	ne.	14	se.	3	T.	0.00	Few	Ci.-s.	0	Few	S.	e.
																	1	Cu.	se.			
4	29.99	29.98	72.5	71.0	77	65	65.5	69	65.0	72	0	0	ne.	3	0.00	0.00	8	A.-cu.	e.	0	0	0
5	30.02	29.98	69.0	68.0	73	66	63.0	72	59.5	60	n.	8	ne.	17	0.05	0.00	9	Cu.	ne.	Few	Cu.	ne.
6	30.04	30.00	69.0	68.0	74	66	58.0	51	60.0	62	ne.	12	ne.	12	0.00	0.00	Few	Cu.	0	1	A.-cu.	n.
																				1	A.-s.	nw.
7	30.02	29.97	69.8	68.5	76	62	60.0	56	62.5	72	ne.	11	ne.	12	0.00	0.00	1	Ci.-cu.	sw.	3	A.-cu.	sw.
																	Few	A.-s.	0	1	Cu.	se.
8	30.01	29.98	70.0	70.0	77	64	63.0	68	64.0	72	sw.	1	e.	5	0.00	0.00	8	A.-cu.	w.	7	S.	se.
																	Few	Cu.	0			
9	29.99	29.98	72.1	71.0	76	67	65.0	69	66.0	77	e.	9	e.	3	0.00	0.15	7	A.-cu	w.	10	S.	e.
																	2	Cu.	e.			
10	29.99	29.95	71.3	72.0	77	68	65.4	73	67.0	77	n.	1	e.	6	0.00	0.00	5	A.-cu.	w.	10	S.	e.
																	3	A.-s.	0			
11	29.94	29.90	74.0	73.2	77	70	68.4	76	69.2	82	s.	14	se.	9	0.02	T.	5	A.-cu.	0	10	A.-s.	sw.
																	5	S.-cu.	se.			
12	29.96	29.96	74.4	74.0	76	71	69.1	77	70.0	82	se.	9	s.	10	0.00	0.00	7	Cu.	s.	10	S.	ne.
13	29.98	29.95	74.0	74.0	78	72	70.5	84	71.0	86	se.	10	s.	6	T.	T.	2	A.-cu.	0	9	S.	sw.
																	8	S.-cu.	s.	1	Cu.	s.
14	29.97	29.97	70.2	70.0	74	68	69.0	94	68.0	90	nw.	4	se.	2	0.66	0.26	10	S.	s.	10	N.	n.
15	29.94	29.91	73.2	66.0	74	64	71.0	90	66.0	100	s.	7	ne.	11	0.30	3.13	10	S.	s.	10	N.	ne.
16	29.95	29.94	68.6	72.0	74	64	67.0	92	68.0	82	se.	9	e.	4	1.91	T.	10	S.	sw.	8	S.	ne.
17	30.00	30.02	74.0	71.0	78	68	68.0	74	65.0	72	ne.	3	ne.	6	0.01	0.00	Few	A.-cu.	0	Few	Cu.	ne.
																	Few	Cu.	0			
18	30.07	30.07	73.0	73.0	81	67	66.2	70	66.5	71	se.	3	e.	5	0.00	0.00	Few	Cu.	0	Few	Cu.	ne.
19	30.10	30.08	75.0	74.0	80	71	68.0	70	67.0	69	e.	4	e.	4	0.00	0.00	4	A.-cu.	e.	1	Cu.-n.	ne.
20	30.09	30.07	74.0	72.0	78	71	64.0	58	64.0	65	e.	9	ne.	9	0.00	0.00	Few	Cu.	0	0	0	0
21	30.07	29.99	73.0	71.0	77	68	63.5	59	66.0	77	e.	7	e.	3	0.00	0.00	1	Cu.	e.	0	0	0
22	29.97	29.94	72.0	73.2	75	66	68.4	84	67.2	73	se.	5	se.	12	0.27	0.16	6	Cu.	s.	Few	S.	ne.
23	29.95	29.97	67.0	72.5	76	64	65.0	90	69.0	84	se.	6	sw.	5	0.40	T.	10	A.-s.	nw.	6	S.	sw.
24	30.02	30.03	74.0	72.0	78	69	69.2	79	70.0	91	e.	8	e.	5	0.08	0.02	8	A.-cu.	se.	7	S.	e.
25	30.06	30.02	74.4	73.5	79	69	69.0	77	69.0	80	se.	8	se.	9	0.06	T.	8	Cu.	e.	5	S.	ne.
26	30.02	30.03	70.0	72.0	77	68	66.4	83	68.5	84	s.	3	e.	4	0.13	0.10	10	N.	sw.	7	S.	e.
27	30.07	29.99	74.4	72.0	77	69	68.2	73	69.0	86	se.	4	nw.	2	T.	0.00	9	A.-cu.	w.	9	S.	n.
																	Few	Cu.	w.			
28	30.07	30.06	69.1	71.5	74	67	68.0	95	69.0	88	se.	1	se.	4	0.02	0.32	10	N.	sw.	10	S.	se.
29	30.08	30.03	75.5	73.0	80	71	68.0	68	68.0	78	s.	2	ne.	3	T.	0.01	1	A.-cu.	s.	5	S.	0
																	8	S.-cu.	e.			
30	30.10	30.06	74.0	71.2	76	69	69.0	78	67.2	81	e.	3	se.	5	0.00	0.00	10	S.	e.	10	S.	se.
31	30.10	30.07	75.1	73.0	78	69	67.0	66	65.0	65	ne.	6	ne.	15	0.00	T.	2	A.-s.	0	0	0	0
																	2	Cu.	e.			
Mean....	30.023	29.998	72.4	71.5	76.9	67.6	66.3	73.3	66.5	77.4	se.	6.2	ne., e.	6.7	3.91	4.18	6.3	Cu.	e.	5.1	S.	ne.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

RAINFALL IN JAMAICA.

Thru the kindness of Mr. Maxwell Hall, meteorologist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following data:

Comparative table of rainfall.

[Based upon the average stations only.]

JANUARY. 1908.

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1908.	Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	21	7.53	6.01
Northern division	22	49	5.63	3.70
West-central division	26	19	2.98	2.52
Southern division	27	30	1.98	1.75
Means	100	....	4.38	3.49

The rainfall over the island for January, 1908, was well above the average. The maximum rainfall recorded was at Shrewsbury, in the northeastern division, 31.45 inches; the minimum rainfall recorded was at Fontabelle, Westmoreland, in the west central division, 0.42 inches.

FEBRUARY, 1908.

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1908.	Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	17	7.57	4.91
Northern division	22	41	6.64	2.42
West-central division	26	20	3.56	2.62
Southern division	27	26	2.42	1.83
Means	100	.....	5.05	2.95

The rainfall over the island for February, 1908, was well above the average. The maximum rainfall recorded was 29.24 inches at Greenvale, Portland, in the northeastern division, and the minimum rainfall recorded was 0.11 inch at Bull Bay, in the southern division.

Chart I. Hydrographs for Seven Principal Rivers of the United States, March, 1908.

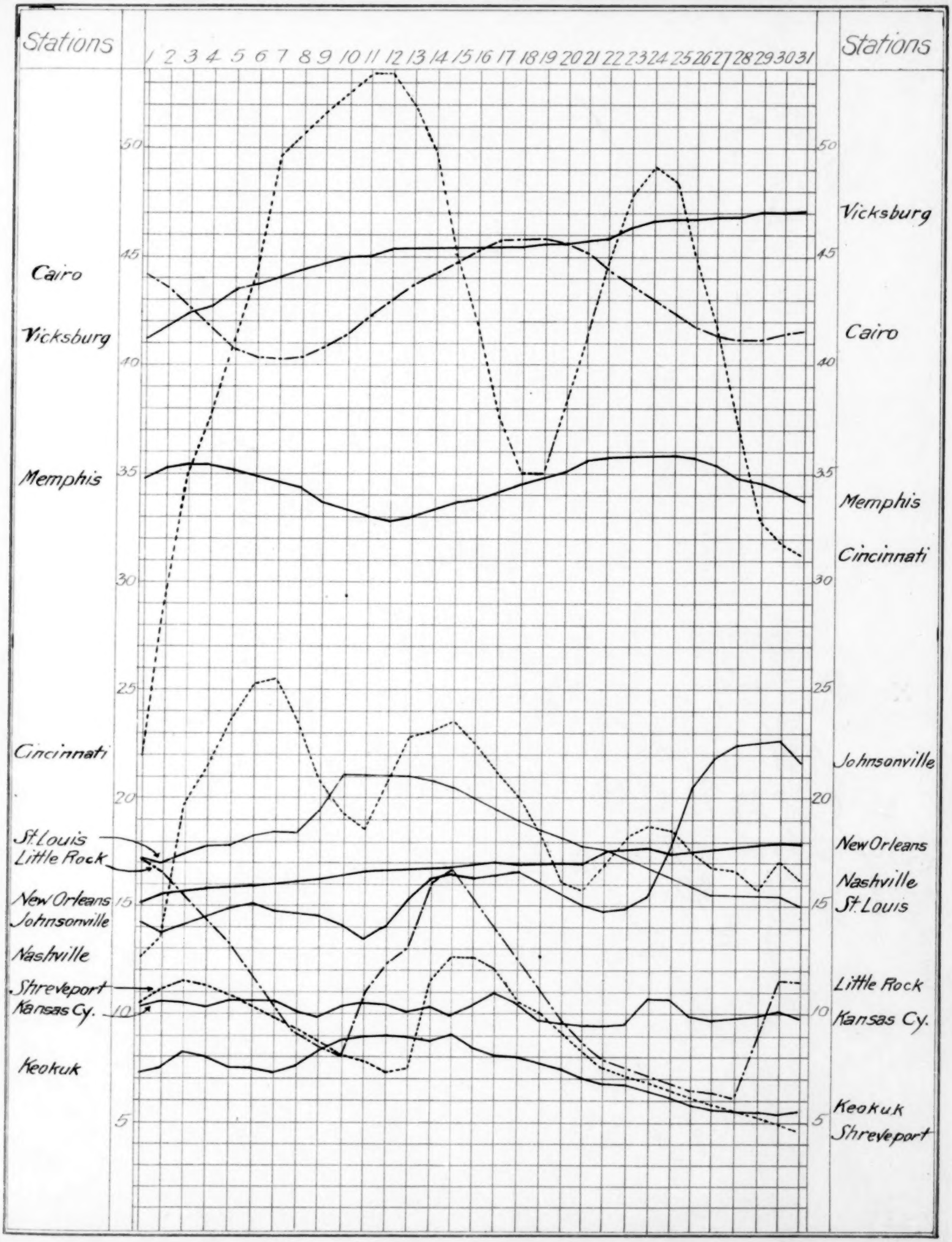
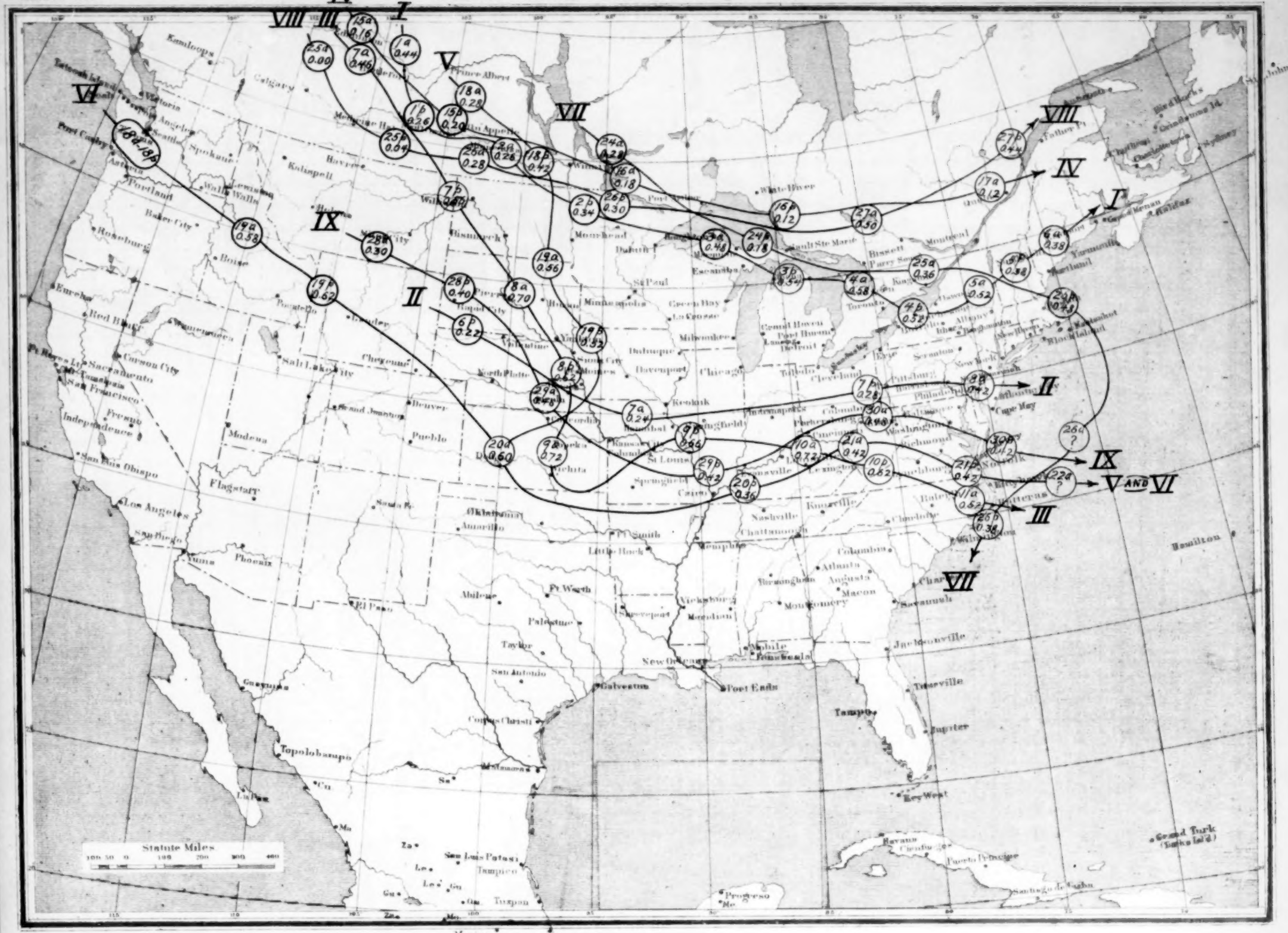


Chart II. Tracks of Centers of High Areas, March, 1908.



Mexico Vera Cruz

Chart III. Tracks of Centers of Low Areas, March, 1908.

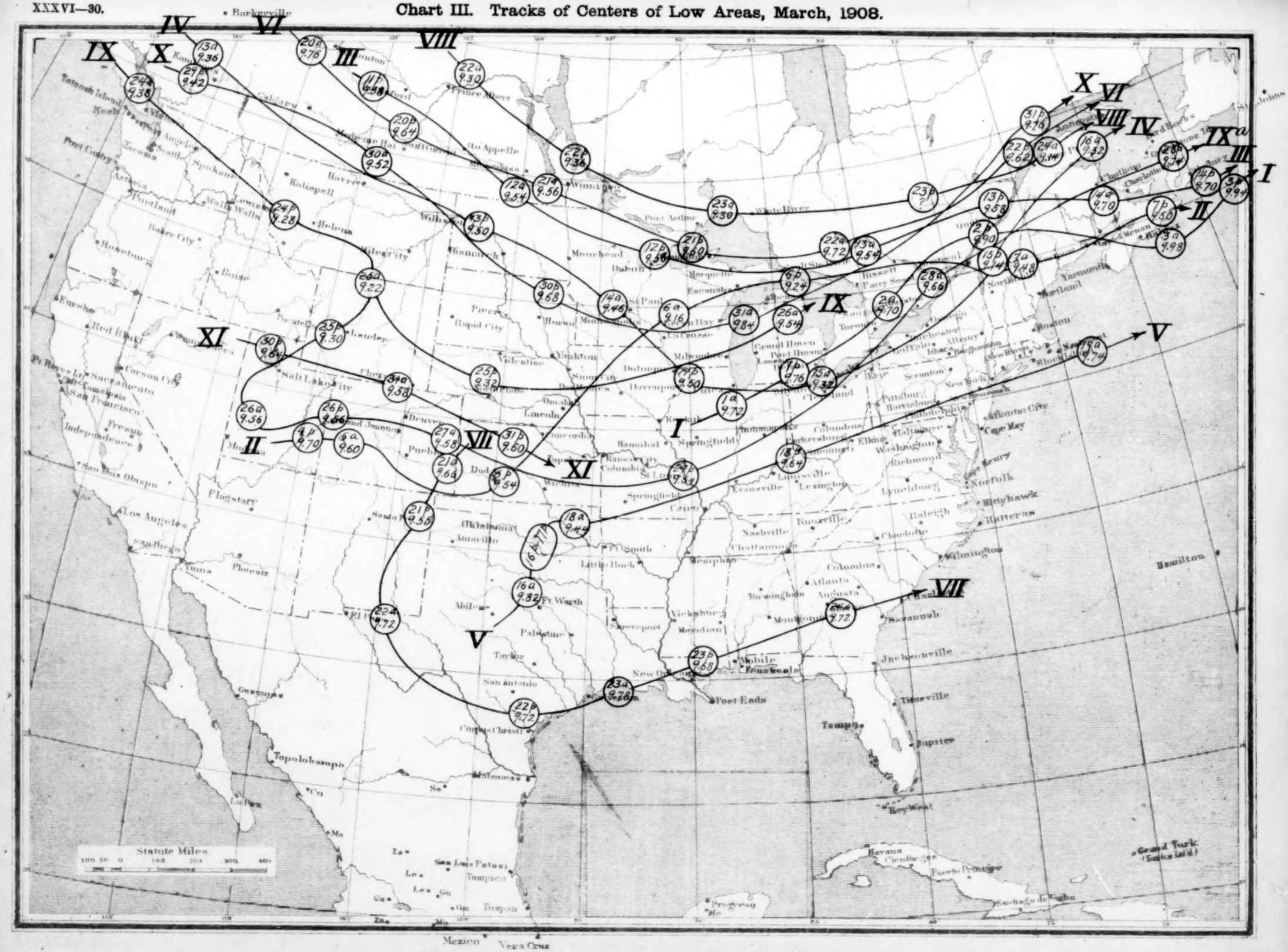


Chart IV. Total Precipitation, March, 1908.

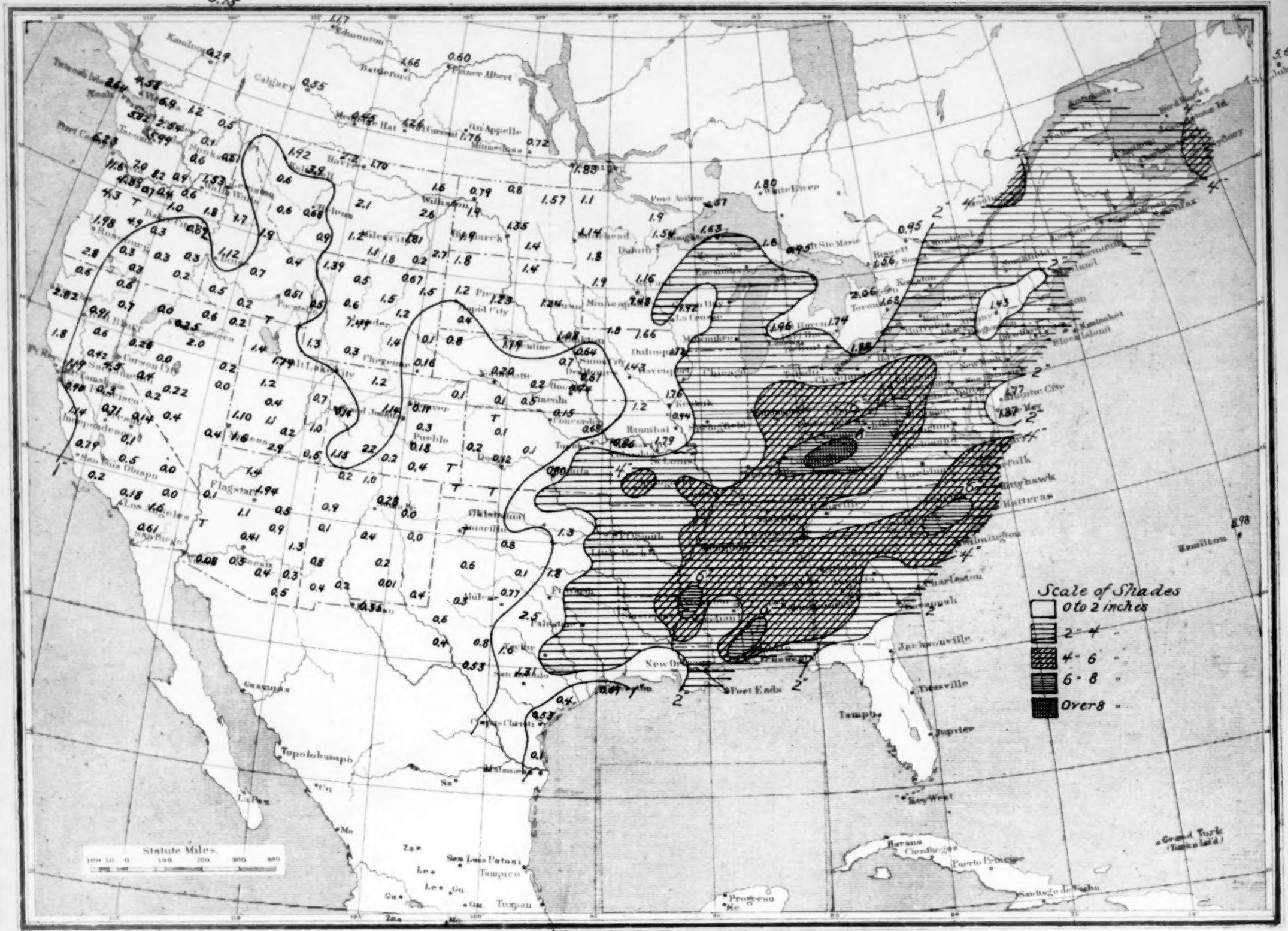


Chart V. Percentage of Clear Sky between Sunrise and Sunset, March, 1908.

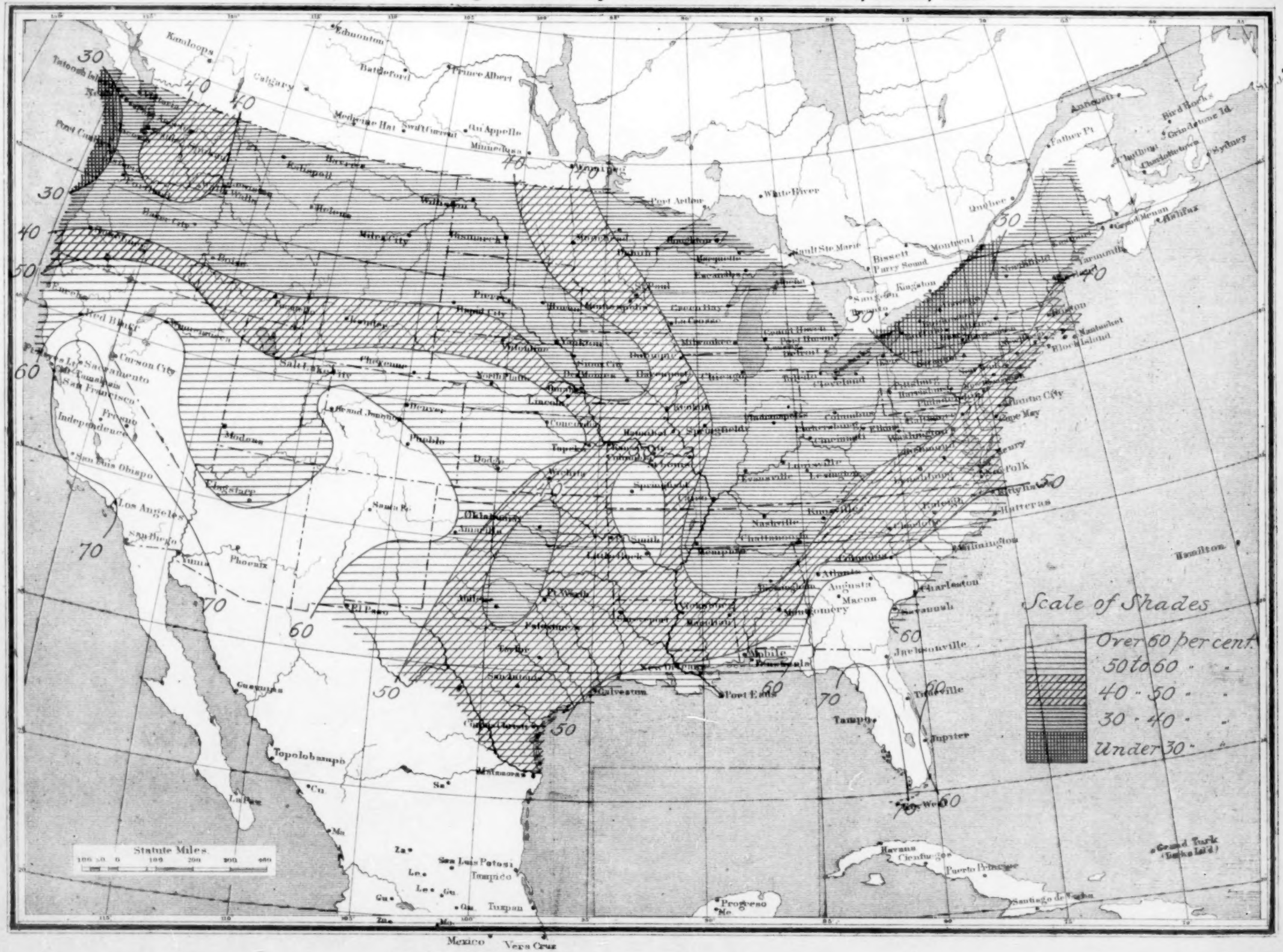


Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, March, 1908.

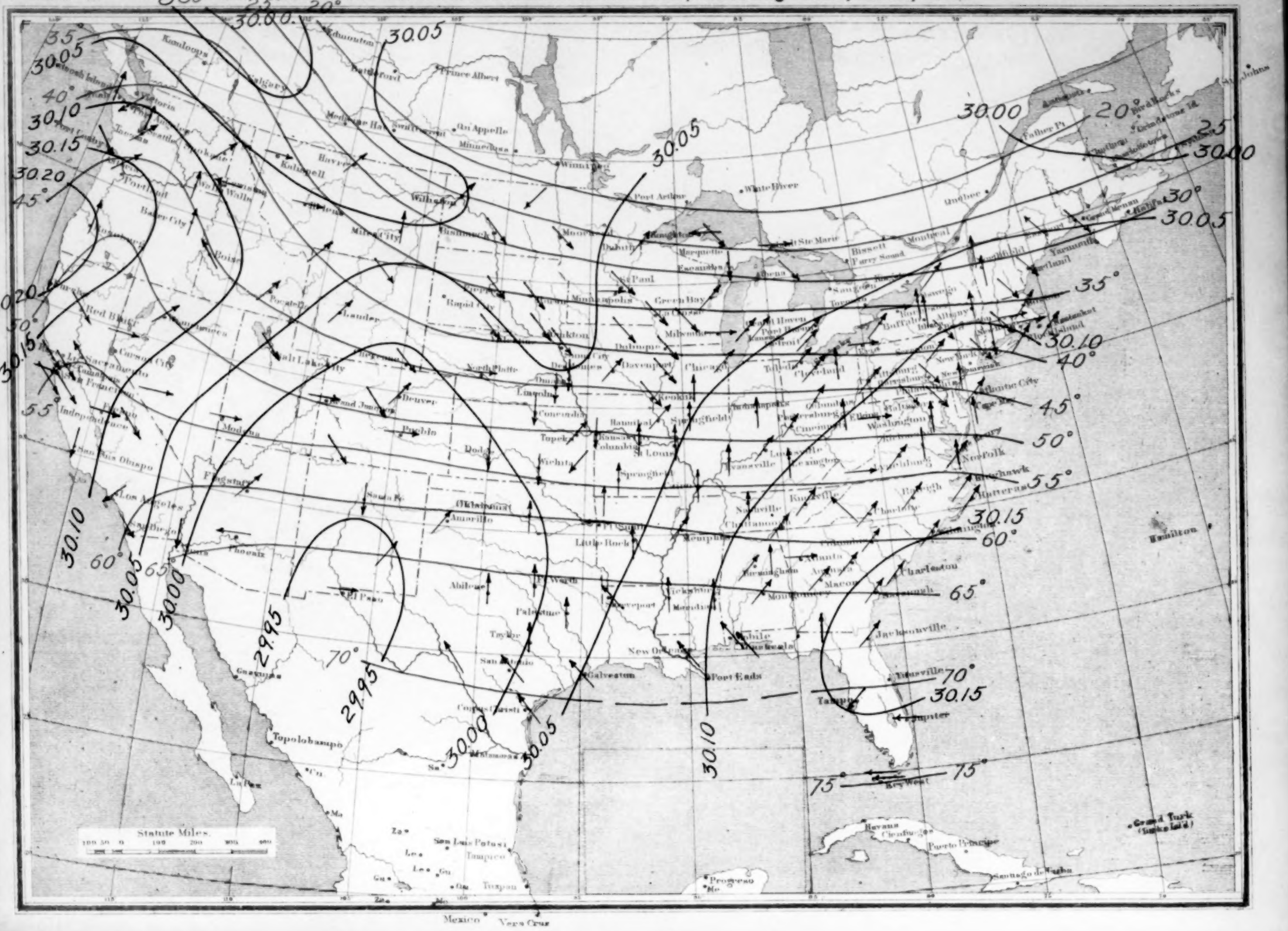


Chart VII. Total Snowfall for March, 1908.

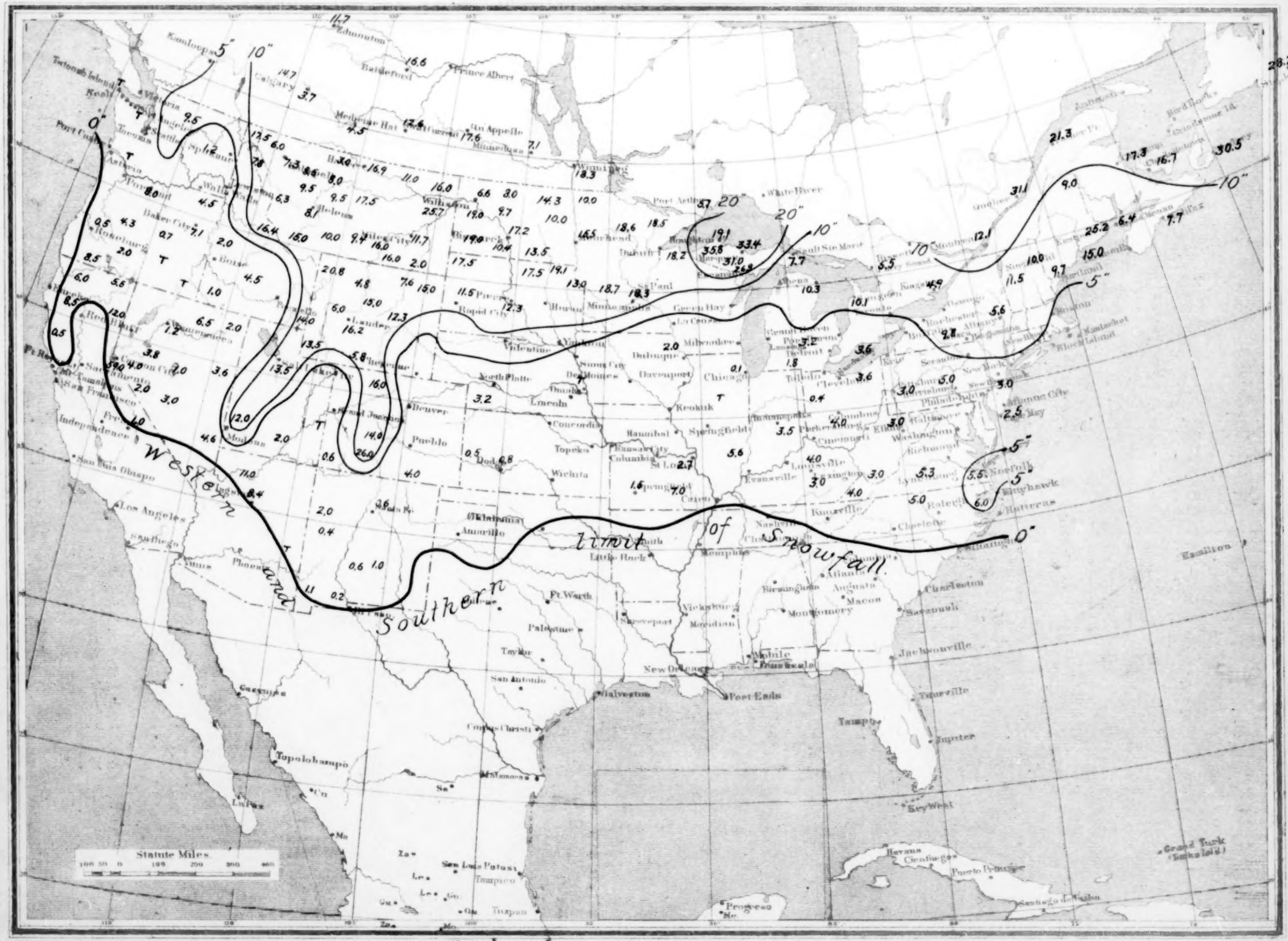


Chart IX. Method of forming Resultant Paths.

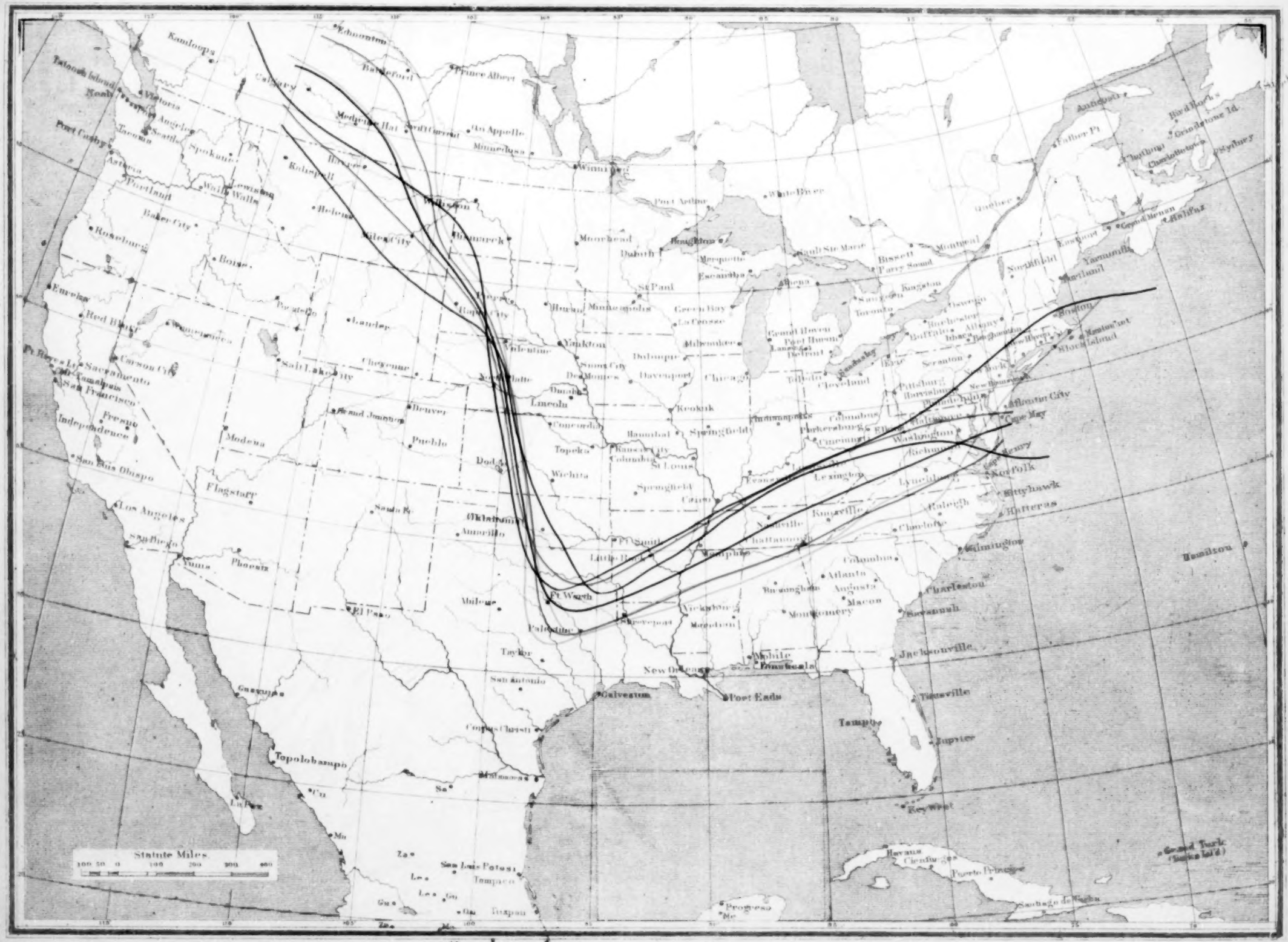


Chart X. Method of forming Resultant Paths.

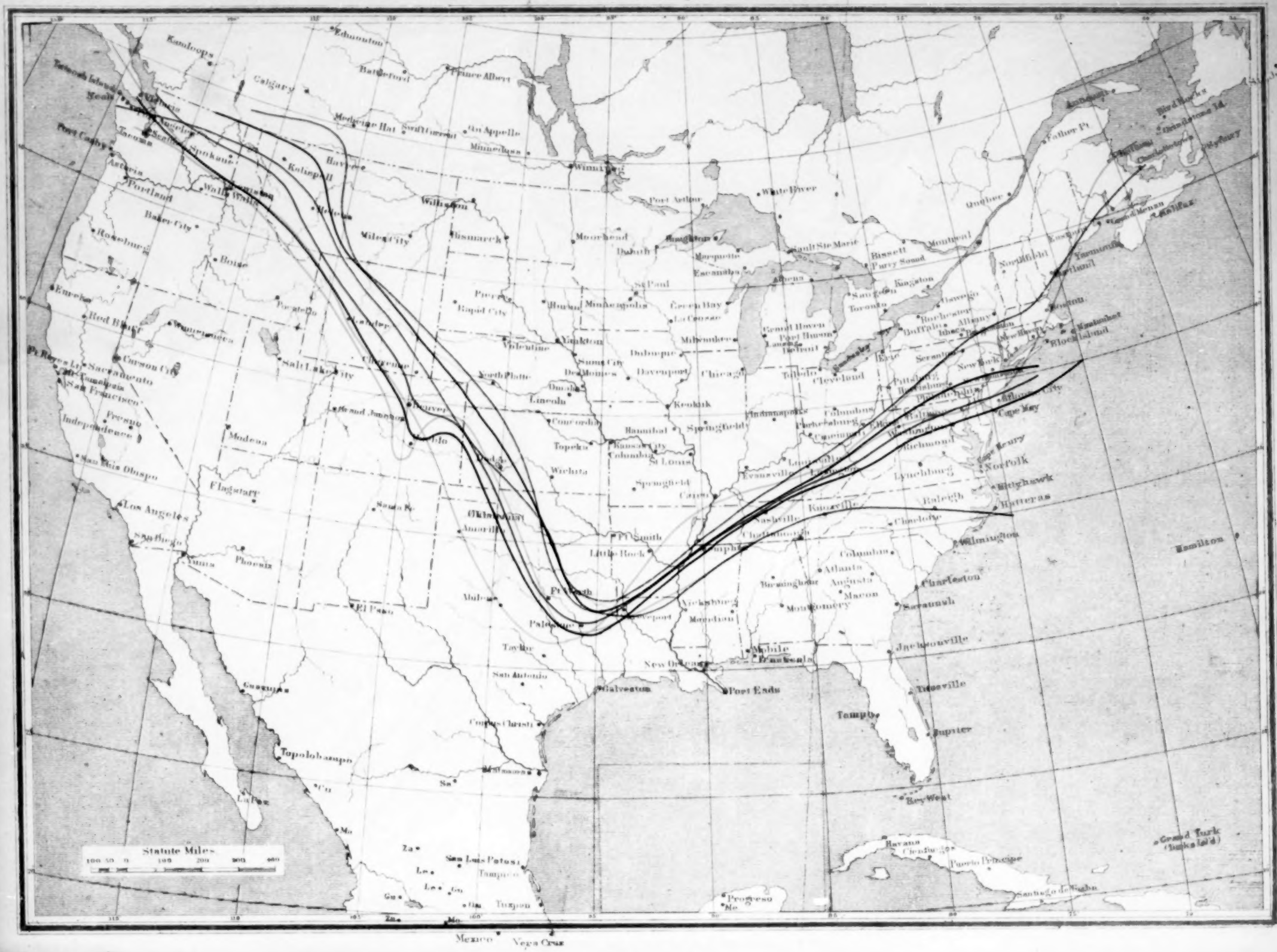


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Chart XI. Method of combining Semifinal Resultants to form Final Resultants.

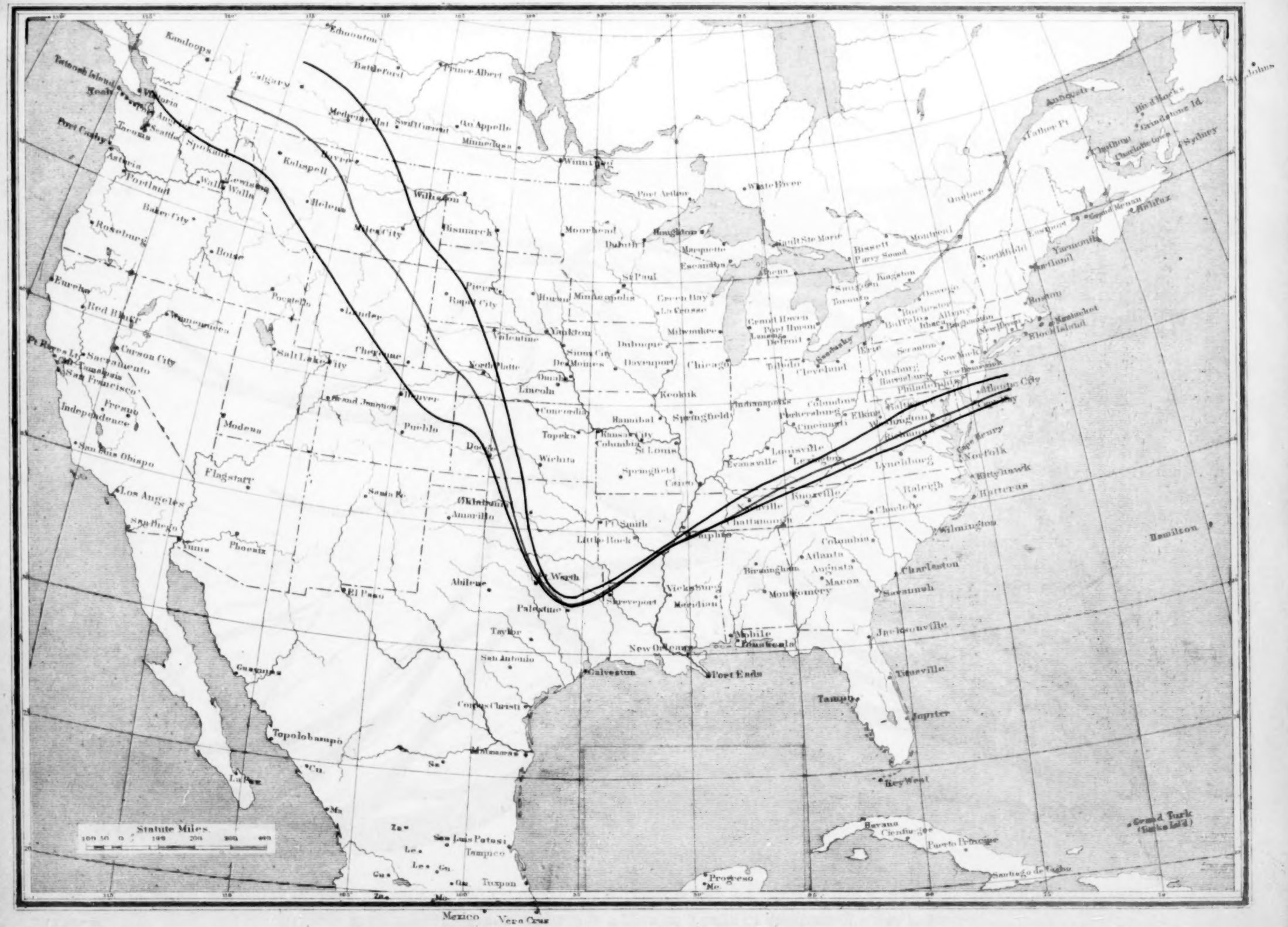


Chart XII. Twenty-seven Apparent Types of Paths of Centers of Low Pressure.

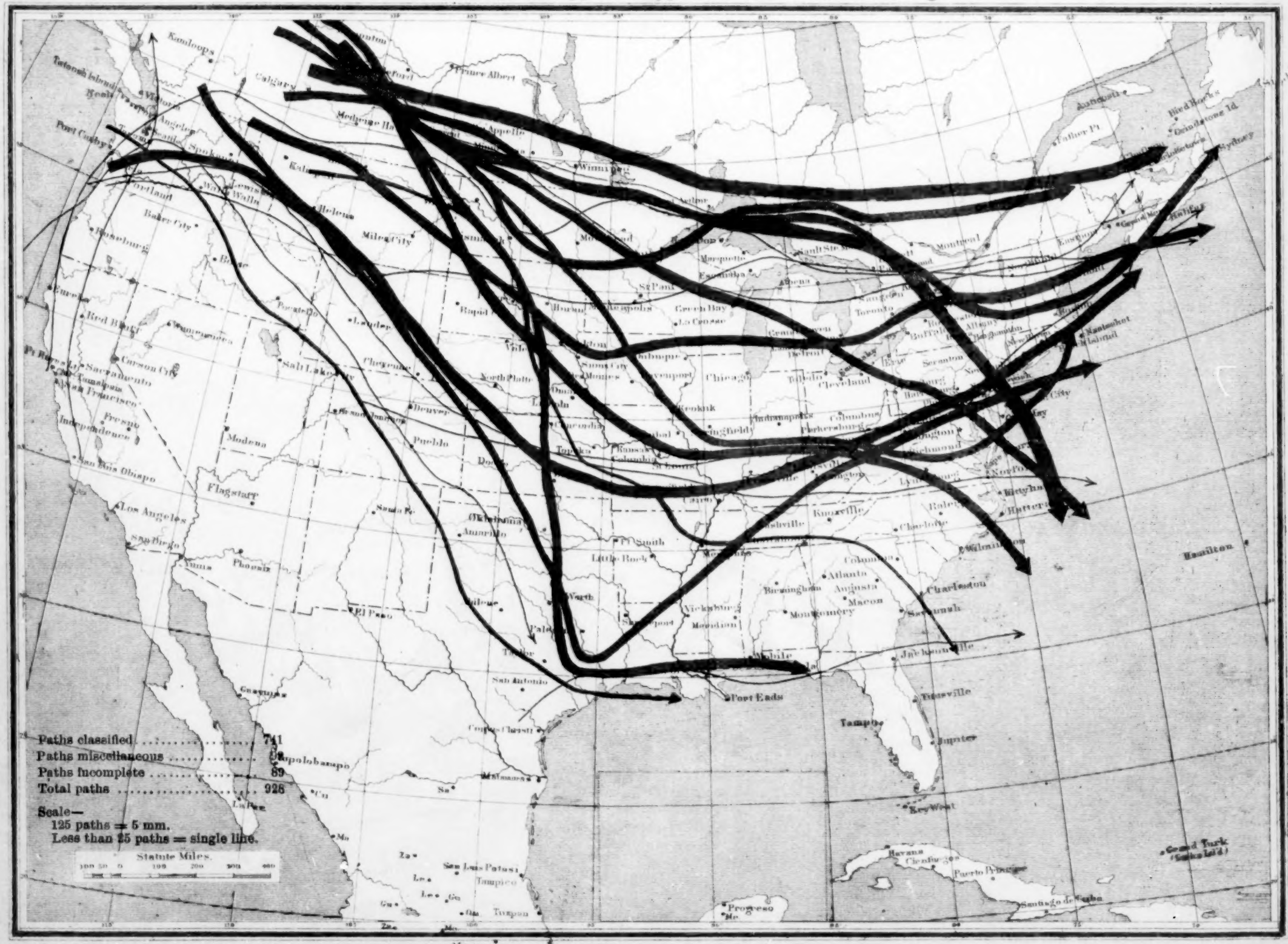
Paths classified 983
Paths miscellaneous 57
Paths incomplete 120
Total paths 1160

Scale—
125 paths = 5 mm.
Less than 25 paths = single line.

Statute Miles.

• Barkerville

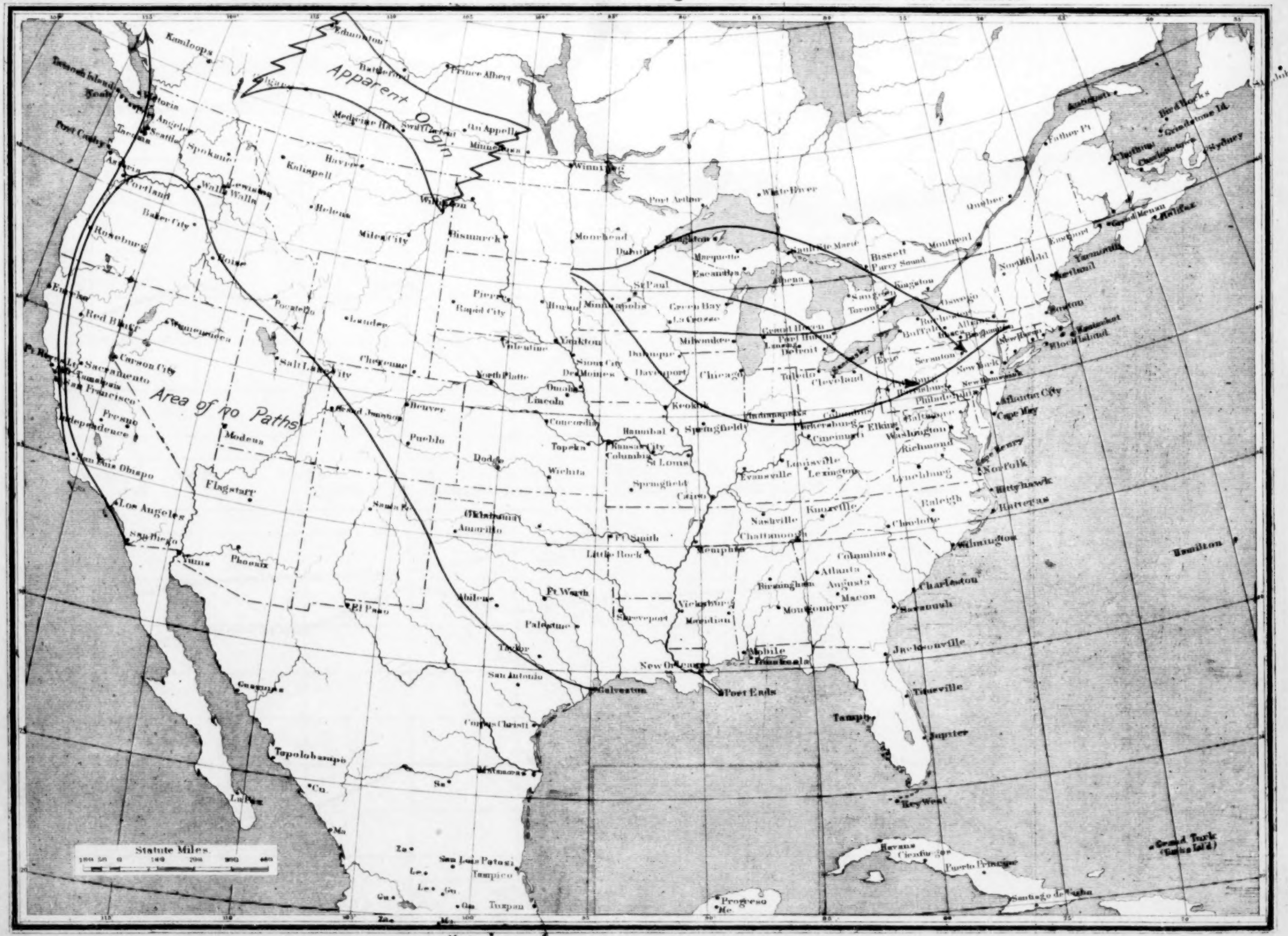
Chart XIII. Twenty-one Apparent Types of Paths of Centers of High Pressure.



Barkerville **Chart XIV. Relation of the Paths of Centers of Low Pressure to Land and Water Masses.**

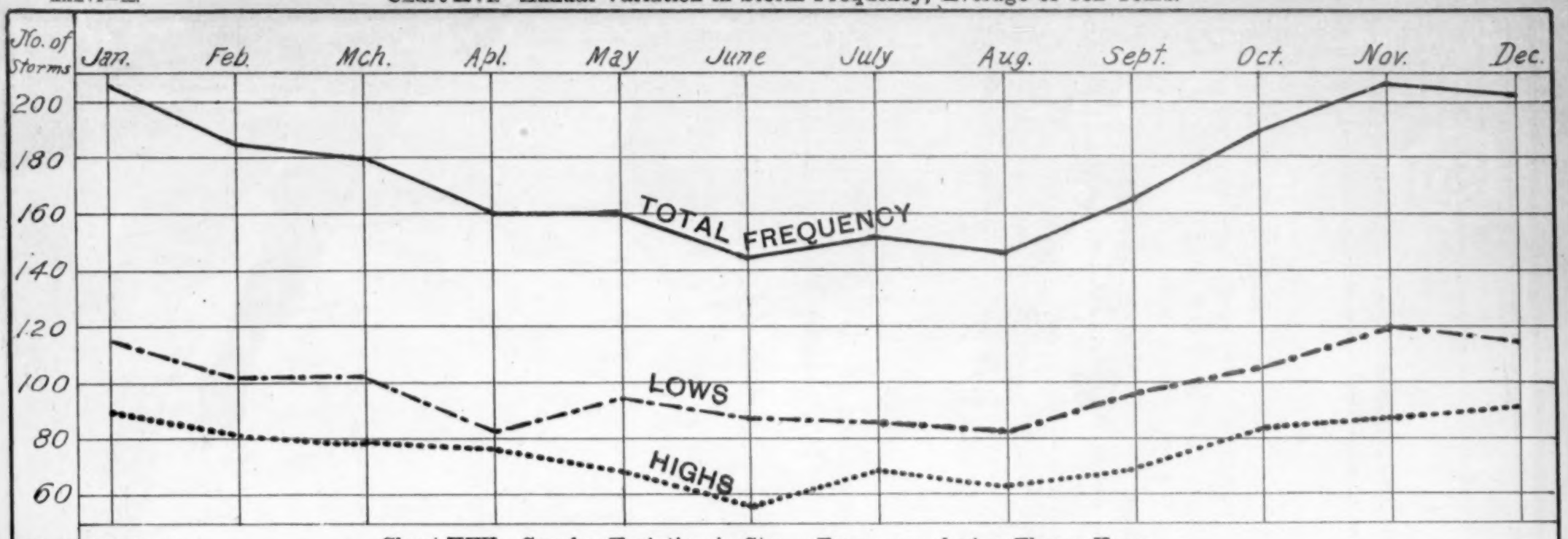
Mexico Vera Cruz

Chart XV. Relation of the Paths of Centers of High Pressure to Land and Water Masses.



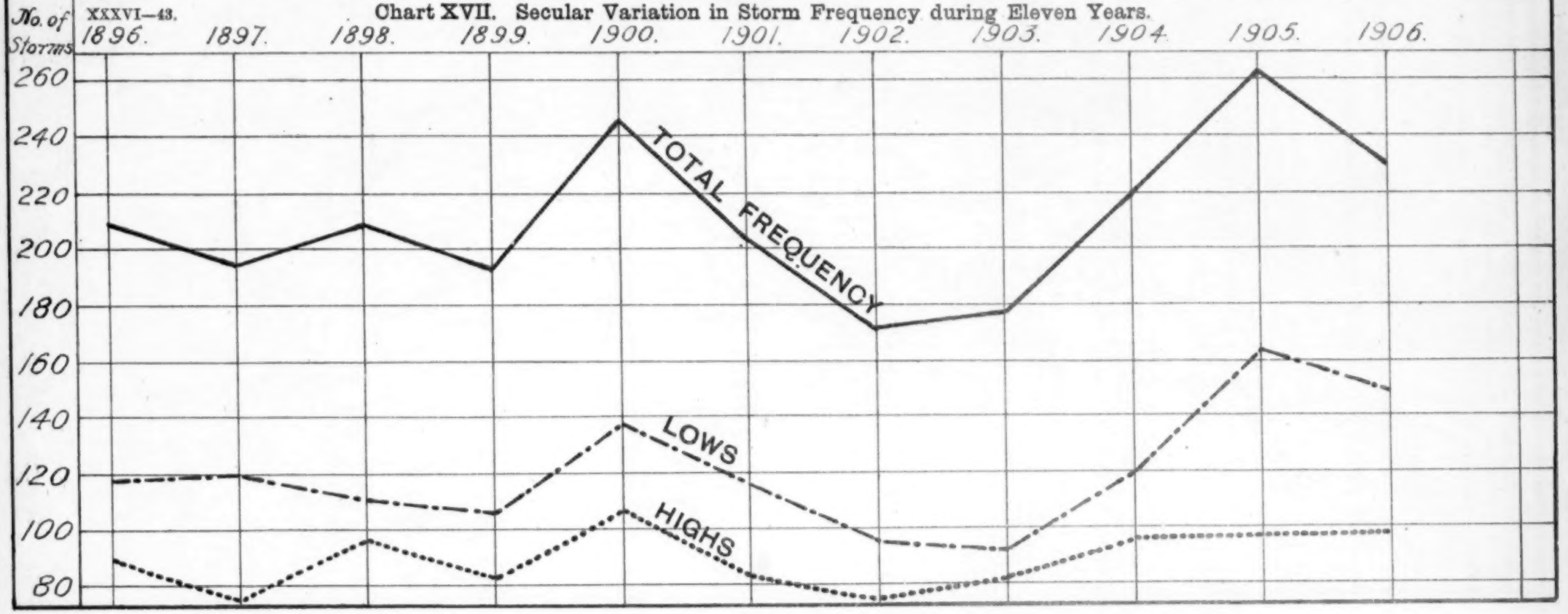
XXXVI—42.

Chart XVI. Annual Variation in Storm Frequency, Average of Ten Years.



XXXVI—43.

Chart XVII. Secular Variation in Storm Frequency during Eleven Years.



XXXVI—44.

Chart XVIII. Two related Paths of Centers of Low Pressure heretofore considered one Path.

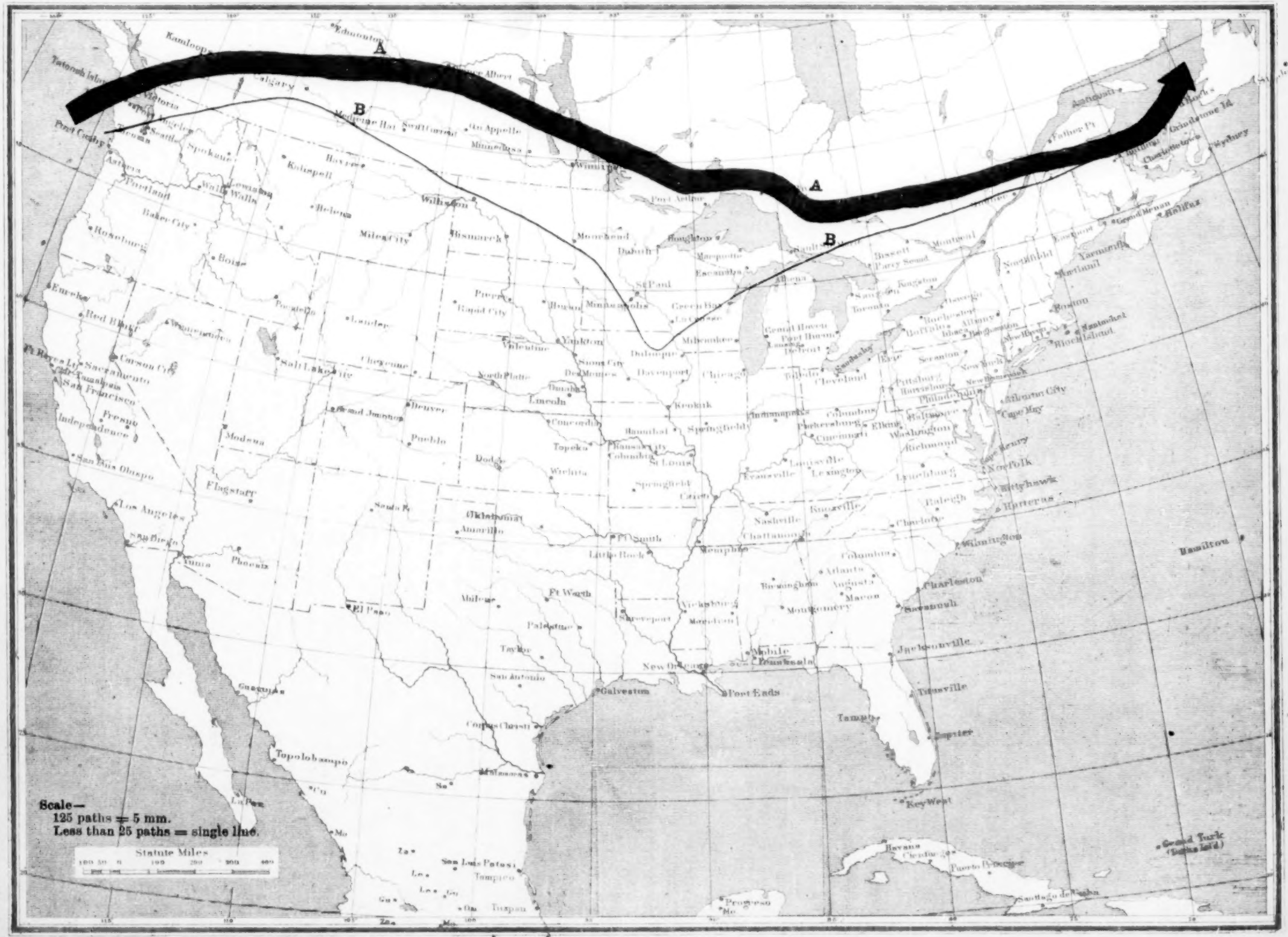



Chart XVIII. Two related Paths of Centers of Low Pressure heretofore considered one Path.